

PRACTICAL

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ELECTRONICS

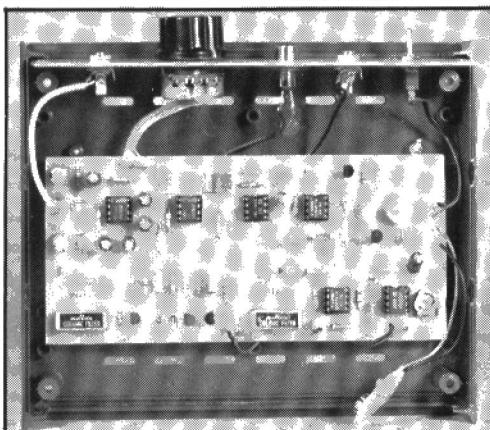
SCIENCE & TECHNOLOGY

DAT
EVOLUTION



BUILD A
SPEECH
PROCESSOR

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS



CONSTRUCTIONAL PROJECTS

RF SPEECH PROCESSING by The Prof	12
Following on from his article in PE Sept 87, the Prof discusses the merits of rf speech processing and describes a low cost practical circuit.	
TEACHER COUNTER — PART TWO by Tim Pike	26
Constructing a simple two digit display gives students a chance to step up their mark count ratio at the end of this GCSE series.	
WEATHER CENTRE — PART THREE by John Becker	34
Digital conversion, monitor alignment, a bit of vanity on the frontal systems and we're ready for computer controlled weather charts.	

SPECIAL FEATURES

DAT EVOLUTION by Barry Fox	20
How soon DAT will find market acceptance remains to be seen but the technology involved has an interesting history and other possible applications.	
HAS ANYBODY HERE SEEN DAT? by Wayne Green	30
An exclusive report by the renowned US publisher and Presidential candidate on the recent exhibition held in Las Vegas, with special reference to the impact of DAT.	
SATELLITES — PART THREE by Mike Sanders	41
Intelsat VI is ready for launching; analogue replaces digital; aerials become more refined; and satellites go into publishing as well as forecasting and navigation.	
SEMICONDUCTORS — PART SIX by Andrew Armstrong	48
The availability of power mosfets increases as the market grows, and it is time to look at the realities of their advantages and disadvantages.	

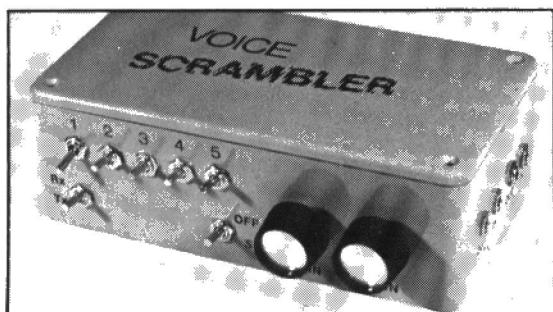


REGULAR FEATURES

EDITORIAL by John Becker — Satellite tv competition	9
LEADING EDGE by Barry Fox — VHS, CD and Britain	8
SPACEWATCH by Dr. Patrick Moore — The ashen light of Venus ..	46
INDUSTRY NOTEBOOK by Tom Ivvall — Ruling the waves	57
SATELLITE TV COMPETITION The Winners	61
READERS' LETTERS — and a few answers	39
POINTS ARISING	47

PRODUCT FEATURES

MARKETPLACE — what's new, where and when	4
ARMCHAIR BOOKSHOP — books to increase your knowledge	54
BOOKMARK — reviews of newly published books	56
PCB SERVICE — professional PCBs for PE Projects	60
TRACK CENTRE — the PCB track layout page	32
BAZAAR — Readers' FREE advertising service	58

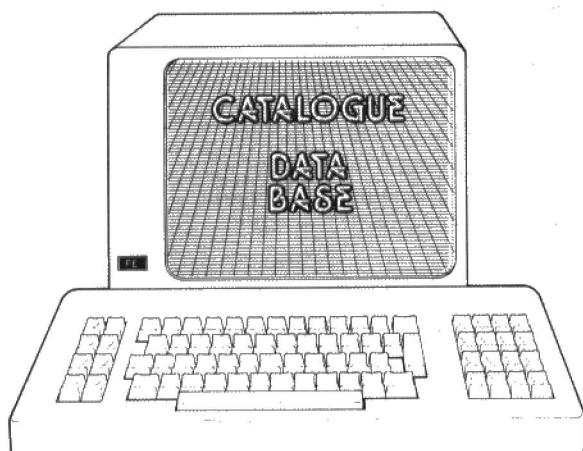


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THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS



We have recently received the following catalogues and literature:

The Institute of Acoustics have published their Acoustics Index for 1987-88. It covers basic acoustics ideas, reviews, sources, standards and lab reports etc. For those whose professional interest lies in this field the price of £55 is probably not unrealistic. **The Institute of Acoustics**, 25 Chambers Street, Edinburgh EH1 1HU.

BEITA Members Yearbook 1988. Annual list of members and essays on business and technology applications, including business and computer systems, electronic typewriters, microfilm etc. **Business Equipment & Information Technology Association**, 8 Southampton Place, London WC1A 2EF. 01-405 6233.

Matthey Electronics. Video delay line catalogue giving full data on their very wide range of broadcast quality delay lines, including HDTV. Also includes rack systems, psus, switched boxes and dsl modules. **Matthey Electronics**, Burslem, Stoke on Trent, ST6 3AT. 0782 85631.

Electronics Data Index Masterfile. A source book of electronic components, manufacturers, distributors, suppliers, and worldwide exhibition diary. This is a controlled circulation publication for engineers and managers, but also available for sale to anyone interested. Published by **BPL Publishing Ltd**, 193 St John Street, London EC1V 4JD. 01-253 2727.

Cirkit emi and power filter cores data book, covering toroidal, E and bus bar cores, available free to engineers and technicians. Covers dc and ac applications and includes design examples and selection charts. **Cirkit Distribution Ltd**, Park Lane, Broxbourne, Herts, EN10 7NQ. 0992 444111.

Electronic Brokers. Catalogue of second user test equipment. An Aladdin's cave of test equipment refurbished to manufacturer's specifications. **Electronic Brokers Ltd**, 140-146 Camden Street, London NW1 9PB. 01-267 7070.

Dean Microsystems have a new catalogue that shows how to design a PC for rugged industrial systems using STEbus. Available through **Bob Squirrell Marketing**, The Old Mill, Reading Road, Pangbourne, Berks, RG8 7HY. 07357 5445.

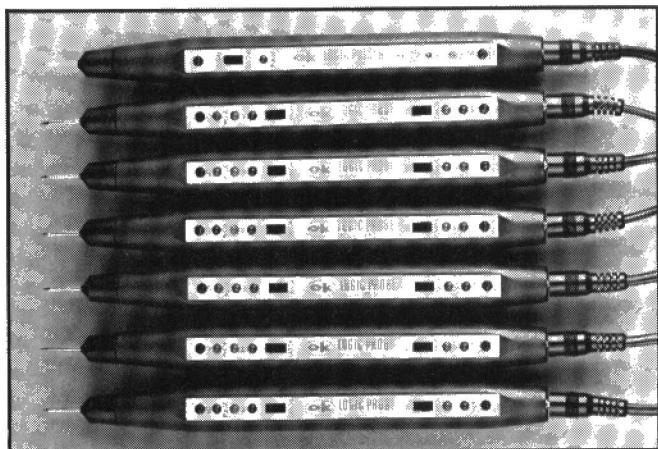
Quintessential Tools

Quinton Tools offer the ideal answer to those constructors and enthusiasts who normally do not have access to low cost professional tools. The company was formed in 1987 and selects tools for inclusion in its range that meet the acceptance of professional users in terms of good quality and long service life. Some tools are imported from the USA, but the rest are from a British manufacturer of high repute.

All listed tools are stocked in depth to ensure off-the-shelf delivery and the resulting price advantage of bulk stocking is passed on to customers. Non-stock items of high quality may also be ordered at realistic prices. Trading is by mail order only, and on a cash with order basis. An illustrated price list is available.

Contact: Quinton Tool Supplies, 52 Grayswood Park Road, Birmingham, W.Mids, B32 1HE. Tel: 021 422 5659

WHAT'S NEW



Fault Probing

OK Industries' PRB series of logic probes are designed to analyse both static and dynamic faults in logic circuitry.

The PRB-20 has hi, lo and pulse indication, automatic pulse stretching, memory and switchable threshold levels. The PRB-20A has the added feature of audible tones which allow the user to detect hi/lo conditions without seeing the probe indicators. These instruments will also detect over/under voltage conditions at the tip or at the power supply. 20MHz bandwidth and 25ns pulse detection are guaranteed.

The PRB-50 expands the frequency response to over 50MHz (80MHz typical).

allowing detection of pulses as narrow as 10ns. PRB-100 is a high-speed digital logic probe. It guarantees a bandwidth of 100MHz and pulse detection down to 5ns, enabling the tester to troubleshoot the fastest logic circuits. Furthermore, it can take place of an oscilloscope by capturing critical short duration events while allowing the operator the freedom to move quickly about the circuit to locate the source of the fault.

Prices, excluding vat and post, range from £21.08 for the PRB-20 to £39.40 for the PRB-100A.

Contact: OK Industries UK Ltd., Barton Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants, SO5 5RR. Tel: 0703 619841.

DC to Mains

Abulon Electronic Systems has launched a new range of portable low cost, high quality static sine-wave inverters.

The units provide ac power at mains voltage from 12V to 24V batteries. The inverters give a stabilised sinusoidal output voltage and are protected against overload, short circuit and reversed polarity supply.

The inverters are ideal for protecting microcomputers from all power related problems, eg loss of data due to power failure and damage caused by surges and power disturbances.

Their other applications are wide and versatile, for example: as the power source in mobile radio stations, boats, caravans, lighting, colour tv, video recorders, hifi, power tools etc. Prices start at £195 for a 12V 100W converter.

Contact: Abulon Electronic Systems, Unit 233 Stratford Workshops, Burford Road, Stratford, London E15 2SP. Tel: 01-471 9644.

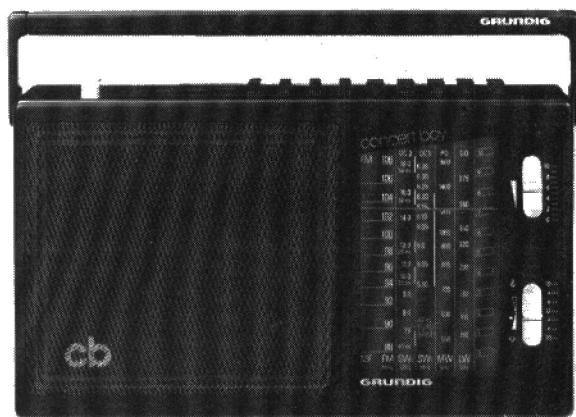
Gigahertz Gen

STG Instrument Services now offers the compact Marconi 2022C signal generator which has frequency, phase and amplitude modulation over a wide frequency range from 10kHz to 1000MHz.

Designed for use in education, maintenance, service application and production, the unit features microprocessor control which enhances the speed of operation via direct keyboard entry of the required settings. A non-volatile memory stores up to 100 settings so further reducing measurement time.

Full GPIB programmability adds greater flexibility and affords faster throughput in systems applications while an electronic trip, which can be reset via the front panel or the GPIB, protects the generator output against reverse power up to 25W from dc to 1GHz.

Contact: STG Instrument Services, Dewar House, Central Road, Harlow, Essex CM20 2TA. Tel: 0279 29522.



Concert Boy

Grundig have added the new Concert Boy 225 to their range of audio products - this brings their portable radio range up to four.

This compact four band radio - mw, lw, fm (with afc and four pre-sets) and 2 x sw: the shortwave coverage is 5.8 to 6.4 MHz (49m band) and 6.8 to 18.5 MHz (41m to 16m). Other features include slider volume and tone controls; large wideband loudspeaker; 1.5 watt music power output; 3.5 mm headphone socket.

The Concert Boy 225 measures 31.5 cm x 18.5 cm x 7.2 cm, weighs approximately 1.5 kilos, and can be mains or battery operated. It is available in black and the price is approximately £39.95.

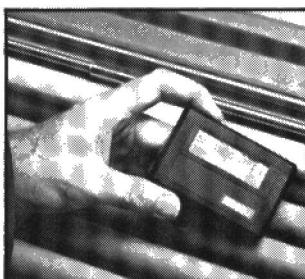
Broadcasting

The Department of Trade and Industry and the Home Office are extending the current feasibility studies into the scope for additional television networks using uhf and mvds to include limited use of vhf bands 1 and 111.

VHF bands 1 and 111, which were used for the transmission of 405-line black and white television, are still available under International Radio Regulations for television broadcasting, and are still used for this in many other countries. In the UK however, they were withdrawn from broadcasting in order to allow for the much needed expansion of private mobile radio services used by the business community. This remains the government's policy. It has however been suggested that there is some scope for a limited broadcasting service to share this spectrum with mobile radio services, and the government have now decided to extend the existing study of the uhf spectrum so as to consider this additional suggestion.

The original feasibility study was announced in October 1987. It aimed to address the technical and financial prospects for both mvds (multi-point video distribution system) and a fifth terrestrial television network in the uhf spectrum. (*See also Leading Edge, PE Mar 88, Ed.*) Consideration of vhf will now form a part of these studies.

As with the mvds and uhf studies, the purpose of the vhf study is to equip the government with an up-to-date and authoritative assessment of the technical options. No decisions will be taken to authorise or make spectrum available for additional services without first considering carefully the possible impact on existing and prospective services, such as the mobile radio services in bands 1 and 111, terrestrial broadcasters, dbs (direct broadcast by satellite) and cable.



Memorable Radio Pager

Mobile personnel who need to be contactable while on the move can now be kept informed with detailed messages, thanks to a new 1200 character message pager from mobile communications specialist, Air Call Communications.

The new pocket-sized radio pager accepts up to 40 detailed messages, displays them on a small 32-character illuminated screen, and lets the holder know that his attention is required either by an audible tone or a flashing light.



COUNTDOWN

If you are organising any event to do with electronics, big or small, drop us a line - we shall be glad to include it here.

NOTE: Some events listed here may be trade or restricted category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

Apr 12-14. Scottish Computer Show. Scottish Exhibition Centre, Glasgow.

Apr 13-14. Laboratory Cambridge. Kelsey Kerridge, Cambridge. 0799 26699.

Apr 26-28. British Electronics Week 88. Olympia. 0799 26699.

May 8. Swindon & District Amateur Radio Club annual rally and hobbies fair, including display support by the British Science Museum, helicopter trips, and a steam engine rally. It looks like an excellent day's outing at Wroughton Airfield, Nr Swindon, Wilts. 0666 89307.

May 12-14. Compfest 88 - National Computer Festival. Telford Exhibition Centre. 0952 505522.

May 18-19. Laboratory Manchester. New Century hall, Manchester. 0799 26699.

May 18-20. ShowTech 88 Berlin. International trade fair and congress - entertainment technology. Berlin exhibition ground.

May 24-26. Computer North. G-Mex Exhibition Centre, Manchester.

Jun 8-9. Infrared Technology. Wembley Conference Centre. 0799 26699.

Sep 6-8. Coil Winding. Wembley Conference Centre. 0799 26699.

Sep 14-18. PCW Show, Earls Court. 01-636 3205.

Sep 27-30. DES. Design Engineering Show. National Exhibition Centre, Birmingham.

Oct 18-20. Internecon. Electronic Packaging Show. Metropole Convention Centre, Brighton.

Nov 1-3. Custom Electronics & Design Techniques Show. Heathrow Penta. 0799 26699.

Because of its ability to store so many messages in any combination of letters, numbers and punctuation marks, it is claimed by Air Call to be a low-cost alternative to mobile telephones.

Thanks to the company's extensive public radio paging network, messages can be received by the new pager in the vast majority of the UK's business centres.

The pager is available for outright purchase at a cost of £245, or can be rented, including airtime, from Air Call at an approximate price of £32 per month.

Contact: Air Call Communications Limited, 176/184 Vauxhall Bridge Road, London SW1V 1DX. Tel: 01 834 9000.

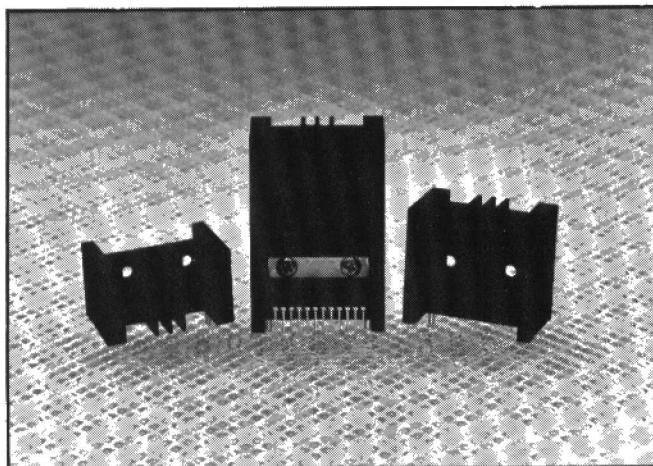
Moving PCW Show

Personal Computer World Show organisers Montbuild Ltd, have announced a change of venue for 1988's event. The show will move from Olympia, and will take place from 14-18 September 1988 at the main hall, Earls Court, London.

The extra space available at Earls Court is the main reason for the move since the show has outgrown Olympia both in terms of floor space and the increased number of visitors that it attracts.

The 1988 PCW Show will be clearly divided into Business, General Computing and Leisure areas, to meet exhibitors needs and visitors interests.

Contact: MPA Ltd, 8-10 Hallam Street, London W1N 5LF Tel: 01-636 3205



Quick Sinking Padman

Six innovative time and money saving alignment pads have come out of Thermalloy, and UK distributors MCP Electronics describes them as capable of cutting heatsink assembly time by as much as 80 per cent, reducing the operation to three easy steps — snap the pad into the heatsink base; slide transistor leads into pad funnel-entry guides; insert assembly into PCB. Tolerances and dimensions are so precise that board insertion can be robotised, while manual insertion becomes a snip.

The pads are already available in six configurations for use with TO220, TO218, and Multiwatt plastic case transistors, and all are designed to be used with a variety of heat sinks according to application. Produced in glass reinforced nylon, with spring steel clips to eliminate mounting hardware, they are designed with a 0.03 inch stand-off.

Contact: MCP Electronics Ltd, 26-32 Rosemont Road, Alperton, Wembley, Middx HA0 4QY. Tel: 01 902 1191.

Euro Supercons

Vacuumschmelze GmbH, one of the world's leading producers of superconductors, are working on the production of new superconducting materials having high transition temperatures. The focal point of the work is to improve the superconducting properties, such as the current carrying capability. It is, however, expected to take another five or ten years to perfect a material suitable for the construction of magnets.

New transition temperature records are frequently reported, and the first signs of superconductivity at -20°C have been experienced. This step forward is most significant, and if research efforts continue successfully, new uses for superconductors will emerge.

Typical applications could be the obvious ones of electric energy transmission and storage, but areas like magnetic separation in ore and mineral processing, environmental protection of lakes and rivers, purification of soil, magnetically suspended railways and so on could all benefit from the technology.

Speculation about the future benefits of superconductors seems to be much in vogue these days, and it is perhaps worthwhile remembering that applications for them currently exist. At present they are primarily used in technical applications, such as tomography in medicine, spectroscopy in material analysis, and research into particle acceleration and nuclear fusion processes. The superconducting materials used in these applications are currently those commercially proven and having transition temperatures of -236°C to -225°C.

Smart Sipmos

Circuit engineers have always been looking for power switches which will protect themselves against destruction in the event of faults. In response to this requirement Siemens have produced the first samples of the smart sipmos semiconductor family. Built in sensors protect the transistors from damage by short circuits, over voltages and over temperatures. The result is a high reliability product that will be especially important in systems where safety is a prime consideration.

One such device is the BTS412A which is a self protecting switch belonging to the profet (protected mosfet) group and intended for use in 12V and 24V automotive and industrial electronic systems. Other devices in the sipmos family and known as tempfets (temperature protected mosfet) offer additional protection in the event of thermal overload.

Taylor DMM Recall

Taylor Electrical Instruments are asking all owners of Taylor Digital Multimeters, Models TD22 and TD23 to return them to the company for a slight modification to be made.

A potential fault has been identified which could result, in certain circumstances, in the screw fixing the battery cover of the instrument becoming 'live' and therefore dangerous to the user.

The modification will be carried out free of charge and modified instruments will be returned as quickly as possible.

Instruments should be returned to: Taylor Electrical Instruments Ltd, Parts & Service Centre, Archcliffe Road, Dover, Kent CT17 9EN. With packages clearly marked on the outside "FOR MODIFICATION".



Digital Light Meter

Solex, the rapidly expanding test and measurement supplier, have recently added the new SL100 Digital Lux Meter to their already comprehensive range. It is ideal for a diverse range of applications in the laboratory, factory floor, industry and so forth.

The unit is a neat, compact portable photometer which can be used for measuring a wide range of illumination levels (0-50,000 lux). Consisting of a

Electronic Growth

A recent report from Siemens Components states that the market for electronic components continues to grow. The dynamic state of this market is most effectively demonstrated by three factors. The first is the rapid growth from 7 billion US dollars in 1970 to around 34 billion in 1985, a five fold increase over the period.

Secondly, the market portion taken by integrated circuits has risen from 38% to 50% over the past five years, and is expected to reach 68% by 1992, by which time two out of three components will be ICs. Although standard ICs such as memories and microprocessors account for much of the growth rate, specialised and customer-specific ICs are gaining ground. These ICs, tailored to particular customer requirements and applications, represent the third factor. They are experiencing the strongest growth area of all integrated products, and their share of the IC world market is forecast to rise from the current 35% to about 45% over the next ten years.

digital unit with a separate photo-electric cell, the main features include a highly reliable and durable LSI circuit, in-built low battery indicator, auto zero adjustment, precise and easy readout, and high accuracy. A carrying case is supplied as standard.

£55 is all it costs to enjoy the advantages of this upmarket machine.

Contact: Solex International, 95 Main Street, Broughton Astley, Leicestershire, LE9 6RE.

CHIP COUNT!

This month's list of new component details received —

80C51BH and 80C31BH. CMOS microcontrollers having one tenth of their NMOS counterparts — 16mA at 12MHz and 5V supply, suiting battery powered communications equipment. (ML).

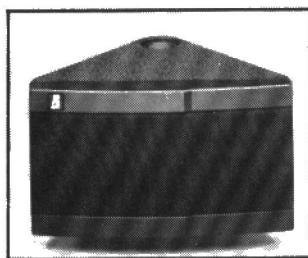
BU603 and BU903. High voltage, high speed power transistors for colour receivers and monitors. Rated at 1350V with current handling of 5A and 6A respectively. (ML).

HD402304. Single-chip CMOS microcontroller optimised for TV and VCR applications allowing full range of channel select functions to be implemented. (HT).

LH4003 and LH4006. Precision closed loop buffers featuring extremely high-gain accuracy of 95% into 50 ohm load. (NS).

(HT) Hitachi, 21 Upton Road, Watford, Herts, WD1 7TB. 0923 246488. **(ML)** Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. 01-580 6633. **(NS)** National Semiconductor.





Speaking Partner

Following on from the success of AR's design-award-winning Powered Partners and styled by the same international design house to match their existing electronics range, the new AR Environmental Partner packs a lot of speaker into a small package.

It is a full-range loudspeaker system with a four-inch polypropylene-coned woofer and 1.25 inch liquid-cooled tweeter in a sleek, wedge-shaped cast aluminium case, finished in smart scratch-resistant black.

The versatility of the speakers makes them ideal in the home, where their angular shape enables them to be fixed in corners, on the floor pointing upwards, or on the wall, held by swivel brackets.

Also ideal for high-quality sound systems in wine bars, restaurants and clubs, they can even be stacked or mounted on car roll-bars, using the integral bracket for fixing to 1.25 inch tubing. They are also weather-resistant and can be mounted in sheltered out-of-doors positions. Sensitivity is a high 88dB for one watt and they are suitable for use with amplifiers rated at between 7 and 75 watts per channel.

The suggested retail price of the Environmental Partners is £149.99 per pair.

Contact: David Berriman Associates, East Barn, Thorpe Morieux, Bury St Edmunds, Suffolk, IP30 0NW Tel: 0284 828926.

Polyboxit

A versatile range of small electronic housings has been launched by West Hyde Developments, the UK distributor for the West German award-winning enclosure manufacturer Bopla.

The Elesett case range is moulded in a two-tone grey colour scheme in high-impact polystyrene providing light weight and good surface finish qualities.

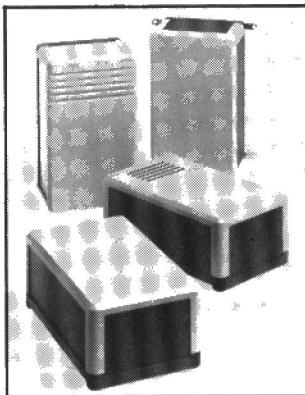
The side and end panels come in either polystyrene or anodised aluminium, and are removable and completely flat for ease of machining or printing. The

plastic panels are reversible to provide an additional aesthetic choice between recessed or flush external surfaces.

As an extra feature the top moulding offers a choice of a plain surface or shallow grooves. Small ventilation louvres in the top and base are a further option. Base mouldings include four M3 threaded inserts for mounting a PCB or sub-chassis, and are supplied with self-adhesive feet or small wall mounting brackets.

As an endorsement of the product's quality and functionality, Elesett gained one of the coveted industrial design awards at the 1987 Hanover Fair.

Contact: West Hyde Developments, 9-10 Park St, Industrial Est., Aylesbury, Bucks HP20 1ET. Tel: 0296 20441.



Emergency Screening

DX 2000, a new communications control system for public security and safety has been developed and released internationally by Philips Radio Communications Systems Ltd.

Philips DX 2000 features a novel method for the system operator to control the communications network using a Microvitec touch-screen which replaces the conventional push-buttons and indicators presentation and offers to the operator fully integrated control of radio and telephone channels on a single screen.

Inherent flexibility of the touch-screen presentation enables easy configuration by the users for different applications and different languages. When combined with the skilful use of colour, as a means of indicating the condition of each of the functions, the Microvitec touch-screen provides the control room operators with an instant picture of the operational condition of the DX 2000 system, thus simplifying decision making.

Contact: Microvitec plc, Futures Way, Bolling Road, Bradford, West Yorkshire BD4 7TU Tel: 0274 390011.



The Reel Revox

Revox, the Swiss-based manufacturer of top quality hi-fi products, has launched a professional reel-to-reel recorder - the C270. Although Revox has been known as the leader in reel-to-reel technology for nearly 40 years, the C270 recorder is only the second Revox machine designed specifically for the professional market (the first was the PR99).

The totally new design of the C270 incorporates many features previously only found in more expensive professional recorders such as those made by Revox's sister company STUDER. Some of these features are:

Brushless dc capstan motor - for accurate speed control. AC spooling motors - high speed spooling and optimum tape handling. Phase linear record/replay circuits - optimum sonic performance. Easy edit mode - Manual movement of right hand spool activates the left hand spool and maintains exact tape tensions at all times. Large vu meters with peak led indicators at +6, +9, +12 dB. RS 232 Serial Port allowing full remote control of all functions and connection to system controller. Fader start/external varispeed connection allowing external control of capstan speed. Easy access to all audio boards allowing alignment to be completed without removal from case or console.

The Revox C270 Recorder is priced at £2490 excluding vat and is available now.

Contact: F.W.O. Bauch Ltd., 49 Theobald Street, Boreham Wood, Hertfordshire WD6 4RZ. Tel: 01-953 0091.

Supersafe Mains Plug

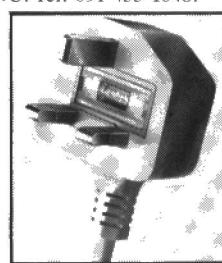
Feller UK announces a moulded 13A mains safety plug with insulated pins. The new plug, for use with Feller power supply cords and cord set assemblies, has the ASTA approval and conforms with BS 1363/A.

The new plug is directly moulded, not an ultrasonically welded hollow shell type. Pins are solid, not folded hollow-core types. The plug is the only one currently available with its wires directly crimped into the pins.

Good electrical isolation and mechanical integrity are provided by the plug's seamless moulded body. Part-sleeved live and neutral pins ensure that fingers cannot touch the pins when the plug is only partially inserted. A transparent plastic fuseholder enables quick and easy access to the fuse from the front of the plug, and allows the fuse current rating to be seen at a glance.

Power supply cords and cord sets incorporating the new plug are available in a variety of cross-sections, lengths and colours.

Contact: Feller (UK) Limited, Unit 1, Middlefields Industrial Estate, Throckley Way, South Shields, Tyne and Wear, NE34 0NU. Tel: 091 455 1048.



LEADING EDGE

By Barry Fox – Winner of the 1987 UK Technology Press Award

LABEL PRINTED IN BRITAIN

Despite efforts, the manufacture of consumer electronics in Britain is trickling away, while Japanese factories in the UK are reduced to assembling overseas-manufactured parts. One reason is that world competition is coming to bear on the Japanese.

“It seems to be the week for shutting factories in Britain” said an American analyst at the end of January, when he heard that the J2T factory at Newhaven, which employs 270 people to make VHS video recorders, was ceasing production.

J2T is a joint venture between JVC of Japan, Thomson of France and Thorn EMI of the UK. Back in 1978, when JVC first planned the manufacture of vhs recorders in Europe, it was to have been J3T; JVC, Thorn EMI, Thomson of France and Telefunken of Germany. Then, in 1981, the French government nationalised Thomson, who dropped out.

So J2T was born and took over old Telefunken and Thorn factories in Berlin and Newhaven. Production of vcrs began in 1982. A Thomson factory at Longwy in France produced mechanical parts. At first all this “production” was little more than screwdriver assembly of kits imported from JVC in Japan, but later there was more genuine manufacture — eg stuffing circuit boards, albeit mainly with Japanese components.

Later Thomson bought control of Telefunken; then Thorn EMI sold Thomson its Ferguson tv and video division. Thorn decided to get out of J2T, reducing it to JT (JVC and Thomson).

The JT factory in Berlin will continue to produce vhs recorders for Europe. The management at Newhaven are trying to organise a buy out which will let them continue working on a subcontract basis for Berlin.

Explaining the Newhaven shut-down, JVC blamed “deterioration in the video recorder market, brought about by excess global manufacturing capacity, made worse recently by rapidly increasing imports of extremely low-priced video recorders from the Far East”.

For surely the first time ever, some Japanese companies are now complaining to the Common Market Commission about dumping at below cost by other Far East manufacturers, eg in Taiwan and Korea. The biter has been bit. Until now it has always been European firms, notably Philips and Grundig, who have lodged dumping complaints against the Japanese.

J2T says it needs to “reduce costs” and thinks the closure of Newhaven will “improve the company’s chances of survival”.

JVC, and the other major electronics companies in Japan, are launching Super-VHS, the new version of vhs which uses higher quality tape and higher carrier frequencies to give clearer pictures. Whereas JVC licensed almost anyone to make VHS, in an effort to make the format a world standard over Sony’s Beta and Philips’ V2000, only carefully selected Japanese and European firms will get an S-VHS licence. Sales of S-VHS in Japan are now running at 8–10% of market. The format is due for launch in Europe this Christmas at a price premium of around 20–30% over standard vhs machines.

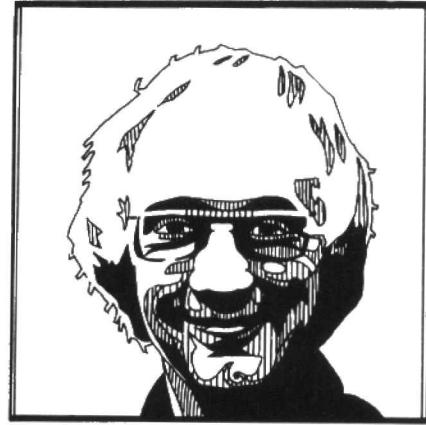
If JVC, who invented the basic vhs system and pioneered the mass production of video recorders, cannot make money on standard vhs against the Far East competition, what hope has a Newhaven management?

Before the Thomson takeover, Thorn had invested heavily in the automated production of tv sets at Ferguson factories in Enfield and Gosport. Now, under French ownership, Ferguson is making workers redundant.

After the sale of Ferguson to France, North London firm Fidelity was the last remaining manufacturer of colour tv sets in Britain under British ownership — the Capparo Group owned by Swraj Paul, a naturalised Indian. Taking the opposite line to Thorn and Ferguson, Fidelity took a considered decision not to invest in automated production machinery. Fidelity did however invest in an r and d team who designed a digital tv set, using the ITT chip set.

Now the company admits it too can no longer compete with the lower manufacturing prices charged by Far Eastern factories. Fidelity has already sacked 100 out of its workforce of 450 and will soon waste most of the rest, leaving only the r and d department, sales force and specialised production line for high value equipment. Bulk manufacture will now be subcontracted to the Far East, mainly Taiwan and Korea.

If Fidelity succeeds it is sad, because this suggests that the only way for a



British consumer electronics company to make money is to become a design and sales front for the Far East.

If Fidelity fails, it will be even sadder because that suggests there may be no way to make money from consumer electronics in the UK.

The record industry is in trouble too, largely because the majors were too myopic to see the potential of digital compact disc. Polygram is shutting down its Walthamstow analogue tape and disc pressing plant. This leaves only CBS at Aylesbury and EMI at Hayes as majors still manufacturing vinyl lps, singles and cassettes in Britain. EMI has a cd factory in Swindon. None of the other majors build in Britain.

Polygram employed over 300 at Walthamstow, making around 50 million lps, singles and cassettes a year. But over 30% of Polygram’s music sales are now on cd; the company (owned by Philips) has already shut down analogue plants in Italy, France and Sweden, leaving Baarn in Holland and Hanover in West Germany as the main suppliers for Europe. WEA and RCA already import from Germany.

Polygram’s cd factory in Hanover, now run by Philips and Du Pont, is the largest in the world. As PDO themselves say: “Anyone who now invests in a new cd plant, is throwing money away”.

There are already too many factories producing too many cds round the world for the market to be profitable for newcomers. Factories in the Far East have brought the price of pressing a cd down from £2 to well under £1.

British government statistics show that in 1970 not a single Japanese manufacturer was based in Britain. Now there are around 60, many of them making consumer electronics. And the pattern looks likely to repeat across the board. For years I tried to stay loyal to genuine British cars. When the gear box on my new Metro MG started failing at 13,000 miles, it took 9 months and 27 letters to get Austin Rover to pay half the repair bill. I replaced the car with a Nissan, because at least that Japanese company has a factory here.

Buying British could soon mean nothing more than buying something which is “made in Britain” by someone else.

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EDITORIAL COMMENT



SATELLITE COMPETITION

So now we know the fortunate winner of the PE satellite tv receiver competition. The details are on page 61, together with the names of the runners-up.

There were several people amongst the final selection to whom we could have awarded the prize, though we were a little surprised at the number of incorrect answers to the three main questions. We really felt that the answers were so readily obtainable that there would be no difficulty. All three questions were chosen because we believe that they represent significant landmarks in the development of electronics. Marconi's first radio transmission across the Atlantic in 1901 represents to us the birth of the communications revolution, enabling society to communicate over vast distances without direct connection by physical links. Without such freedom, commerce, education and entertainment would be unlikely to reach the world's population as broadly as it does today.

We debated for some time as to whether the invention of transistor in 1947 or the integrated circuit in 1958 was the more significant. Certainly without the transistor, ics could not have been invented, but the ic has led to the miniaturisation of the circuitry that is essential to computer and allied technologies. While the invention of the transistor is perhaps more widely documented than that of the ic, we gave you a healthy clue to the answer by saying that it was invented by Texas Instruments. We know that some of you rang TI to ask them the answer. Reference libraries could also have helped you find the answer.

The introduction of PE in 1964 represented a significant step forward in bringing the whole subject of electronics to a wider audience. Prior to PE, the available magazines implied by their titles that they were to do with radio. PE showed that electronics has far wider applications and that they were within the reach of anyone with a soldering iron and a few pence to spare. The first year of publication could have been worked out from the current volume number. Some of you took the easy way out, and phoned us — we were pleased to tell you and applauded your initiative, as we did those who rang TI.

Question four was, of course, a tie-breaker. Quite naturally, many of you wanted a satellite tv receiver because it would give you a greater selection of entertainment channels, or because you wanted to be the envy of your neighbours. Nothing much wrong with that! We felt, though, that those of you who showed greater imagination and wanted to reap wider benefits from the gift were more deserving. We finally chose "to open new horizons in my hobbies of electronics, computing, radio, tv and astronomy". Well done Mr Cook, enjoy your prize. Thanks, and commiserations to everyone else who participated.

THE EDITOR

RF SPEECH PROCESSOR

BY THE PROF

HOW TO GET A CLIPPED ACCENT

An army drill sergeant's bellows carry across the quad because his clipped vocalisations allow a high average signal level. You can do the same thing electronically to improve the clarity of speech signals — no boots required. This unit uses single sideband (ssb) radio frequency (rf) processing to clip the input signals and filter out distortion.

In the Experimental Electronics article in PE Sept 87, the principles of speech processing were discussed, and some practical circuits for audio speech processors were provided (including a constructional project). The subject of rf speech processing was mentioned, and this is the topic that will be pursued in this month's article. Apart from the general principles involved, an inexpensive but effective rf speech processor project is also included in this article.

DUE PROCESS

I suppose a basic explanation of the "rf" in rf speech processing is in order, since we are talking about what, on the face of it, should be a purely audio process. After all, the input signal is an audio type, as is the processed output signal. However, with an rf speech processor the signal is converted to a radio frequency type, then processed, and finally demodulated back to an audio signal again. This may seem like doing things the hard way, and it is admittedly a much more complex system than simple audio processing. On the other hand, using modern components an rf speech processor can be far less complex than one might expect, and there are definite advantages in terms of performance.

A detailed description of speech processing fundamentals will not be given here as they were discussed in some detail in the previous article. However, to briefly recapitulate, the general idea is to clip the input signal so that the average signal level is boosted. With the unprocessed and processed signals set for the same maximum peak to peak level, the processed signal will sound some 6 to 10dB louder than the unprocessed one. When used with transmitters, PA amplifiers, etc, a speech processor enables the available output power to be used more effectively, and can give much the same effect as a boost in power. Depending on the efficiency of the processing, the effective increase in power is generally around four to ten times. Speech processing can therefore give a very worthwhile improvement in the performance of a system for what



will often be quite low cost when compared to the overall cost of the equipment.

One word of warning that has to be repeated here is that some items of equipment already have some form of built-in speech processing, and any add-on unit is not likely to be of benefit with these. Another point to bear in mind is that some pieces of equipment are designed on the assumption that the input signal will be an ordinary speech type that has a fairly high average to peak amplitude ratio. Using a speech processor with these could conceivably result in over-heating and possibly cause expensive damage as a result of this.

A basic clipping circuit is virtually useless as a speech processor as it results in strong distortion products being generated. These products are harmonic and intermodulation types. The harmonics are simply multiples of the input frequencies. To some extent these can be counteracted using lowpass filtering, and a fundamental signal at 2kHz for example, will produce harmonics at 4kHz, 6kHz, and so on. As frequencies above around 2.5 to 3kHz are not needed for intelligible speech, with high slope filtering these harmonics could be reduced to an insignificant level.

Frequencies below about 300Hz are not needed for intelligible speech, but frequencies from around this figure to about 1.25 to 1.5kHz will produce at least one harmonic within the passband of the output filtering.

Intermodulation distortion is more complex, and is the result of an interaction between two frequencies. It generates sum and difference frequencies, and with 200Hz and 800Hz for instance, the new frequencies would be 600Hz (800Hz - 200Hz) and 1000Hz (800Hz + 200Hz). As a typical voice signal contains numerous frequencies, the result of any intermodulation distortion is to produce a complex spectrum of new frequencies. Again, many of these frequencies will be within the passband of a bandpass filter used to process the output signal.

With simple speech processors the only way to avoid excessive distortion is to use no more than a moderate amount of clipping, and this still gives quite significant levels of distortion. It is a matter of finding a compromise between enough limiting to give a worthwhile increase in "talk-power", and not using so much limiting that the resultant distortion substantially hinders the intelligibility of the signal. Obviously

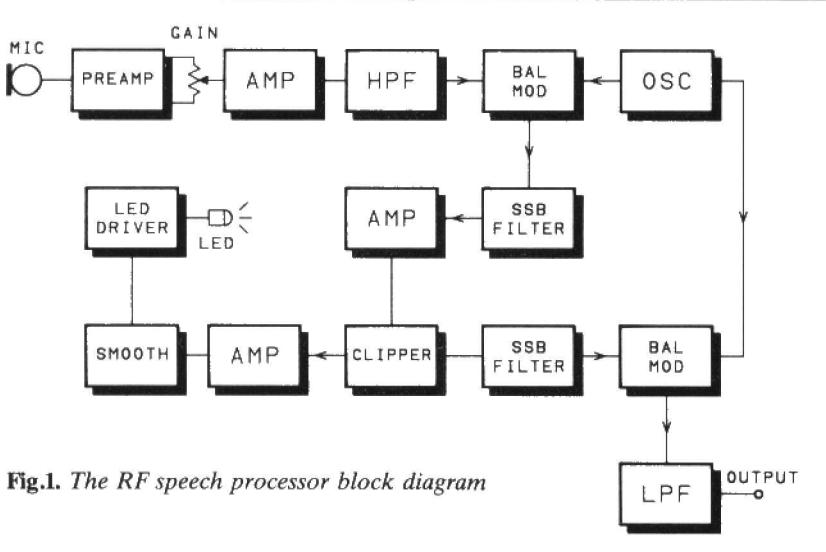


Fig.1. The RF speech processor block diagram

results would be better if large amounts of limiting could be used without producing massive amounts of distortion.

SOPRANO CLIPPING

The method used in the earlier speech processor was to split the audio signal into two frequency bands and to then process these separately, including separate output filters. The narrower bandwidth of the output filters, together with the more limited frequency range applied to each clipping circuit, enables greatly reduced distortion levels to be obtained. A very different approach is adopted with an rf speech processor, and the block diagram of Fig.1 shows the arrangement used in this particular design.

The first two stages are just a preamplifier and voltage amplifier which are needed to boost the very low level microphone signal to a usable level. A gain control is incorporated in this part of the circuit, but note that this sets the limiting level, and does not act as an output level control. The amplified signal is processed by a highpass filter which attenuates signals below about 300Hz, but we will ignore this for the moment.

BALANCED MODULATOR

Next the signal is applied to one input of a balanced modulator, and the other input is fed with the output of an rf oscillator. The balanced modulator is much the same as the ring modulators used in electronic music, but it is operating with one signal well above the upper limit of the audio range. The mathematics of its operation are exactly the same though, with sum and difference frequencies being generated, and the two input signals being suppressed from the output. In this case the rf oscillator operates at about 455kHz, and the sum signal is effectively the audio input signal with all its frequencies raised by 455kHz. The difference signal is a sort

of inverse of this, with the two signals being symmetrical around the 455kHz carrier wave. As a simple example, a 1kHz input signal produces sum and difference frequencies of 456kHz and 454kHz respectively.

This signal is actually just the same as an ordinary amplitude modulation (am) signal of the type used for long and medium wave broadcasts, but the 455kHz carrier wave has been suppressed. The sum signal is called the "upper sideband", and the difference frequency is called the "lower sideband". The two signals together (minus the carrier) form a double sideband suppressed carrier signal. For our present purposes it is a single sideband (ssb) suppressed carrier signal that is required, or to put it another way, the lower sideband or the upper one, but not both.

There are several ways of generating a single sideband signal, but these basically boil down to some system of phasing to remove the unwanted sideband, or a system of filtering. The phasing method may well be perfectly feasible for a unit of this type, but due to a lack of information on this subject I opted for the filtering method. This merely entails feeding the double sideband suppressed carrier signal through a special narrow bandwidth high slope filter which permits one sideband to pass but severely attenuates the other. This is normally achieved using a crystal, mechanical, or ceramic filter, and in this case an inexpensive ceramic filter is used.

FILTER SKIRT

Fig.2 should help to clarify the way in which the filtering operates. The carrier frequency must be set a little way into one of the "skirts" of the filter, so that the wanted sideband is little affected by the filtering, but the unwanted sideband receives strong attenuation. In this case the output signal is the upper sideband,

but by placing the carrier on the opposite "skirt" of the filter a lower sideband signal is obtained.

This system of sideband generation is something of a compromise. The signal produced by middle and high audio input frequencies receives a high degree of attenuation on the suppressed sideband, with what in practice is likely to be around 40 to 80dB of attenuation. Even using quite sharp filtering, the signals produced by low audio input frequencies do not receive a very high degree of attenuation, with perhaps only around 20dB of attenuation. The use of an inexpensive filter does not help, as this inevitably has slightly lower performance than types costing several times as much. It is to minimise this problem that the highpass filter is used ahead of the balanced modulator. This filter attenuates signals at frequencies where very poor sideband suppression will be obtained, and therefore helps to minimise the strength of unwanted sideband components.

CLIPPING

Having obtained a single sideband signal, it is then amplified and fed to the clipping circuit. At first sight this might all seem a little pointless, since the harmonic and intermodulation products will still be generated, just as for an audio signal. However, the point of rf clipping is not to prevent the generation of distortion products, but to make them more easily removed. Things certainly look very promising when the spectrum of new frequencies generated by harmonic distortion is examined. Fig.3 helps to explain what I mean. In (a) the solid lines represent the audio input components, and the broken lines depict the resultant harmonic distortion components (for clarity only the first harmonics are included). This clearly shows that some of the harmonics generated are within the audio passband. In (b) the solid lines depict the upper sideband signal produced from the audio input of (a), and the broken lines represent the harmonics. Obviously the harmonics are all well away from the original input frequencies, and can easily be filtered out.

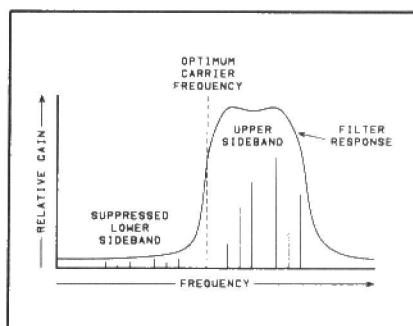


Fig.2. Using a high performance bandpass filter to remove one side band

RF SPEECH PROCESSOR

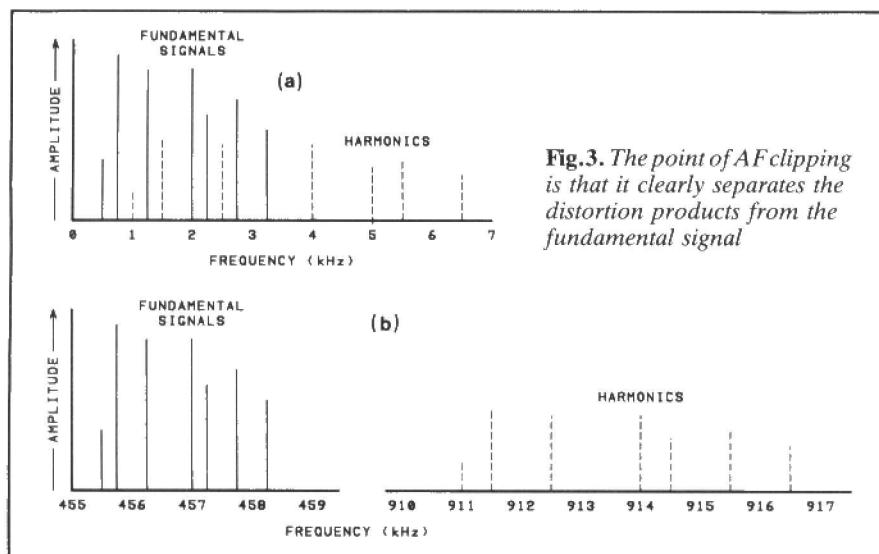


Fig.3. The point of AF clipping is that it clearly separates the distortion products from the fundamental signal

this form of intermodulation distortion. Otherwise harmonics from one sideband react with the fundamental signals in the other to give difference frequencies that are within the frequency limits of the input signal. After demodulation these would produce the same output frequencies that audio clipping would generate. Thus there is no real advantage to rf speech processing unless the signal is converted to an ssb type prior to clipping.

CLIP ROUTING

Part of the clipped signal is fed to an amplifier and smoothing circuit, and the dc output signal from this circuit operates a led indicator via a simple driver circuit. The led simply flashes on when a signal is clipped, and this is a useful aid to getting a suitable clipping level.

The main route for the clipped signal is through another ssb filter. The purpose of this filter is to cut off any distortion products outside the frequency limits of the ssb signal. Many of these will be at either very low or very high frequencies, and could be virtually eliminated using the most simple of filters. Some of these frequencies will lie only just outside the frequency range of the main signal though, and so another high slope filter is needed here in order to give a really clean output signal.

A balanced modulator acts as the demodulator. This is fed with the ssb signal and the output from the same

INTERMODULATION

This gives a rather over-optimistic idea of the performance that can be obtained from an rf speech processor. Remember that there is intermodulation distortion to contend with as well as the harmonic variety. The more straightforward intermodulation products are no real problem as they produce either audio frequencies (the difference signals) or frequencies at about double the carrier frequency (the sum frequencies). In both cases they are easily filtered out.

The intermodulation products that give the problems are the ones produced by an interaction between components

in the ssb signal, and harmonics from other components in the signal. As an example, assume that there are sideband components at 456kHz and 457kHz. The first harmonic of the 457kHz signal is at 914kHz, and this reacts with the 456kHz signal to produce a difference frequency at 458kHz ($914\text{kHz} - 456\text{kHz} = 458\text{kHz}$). Fortunately, this form of intermodulation distortion produces relatively weak distortion products, and many of them are just outside the frequency range of the ssb input signal.

Although there may seem to be no point in removing one sideband from the output of the balanced modulator, this is necessary to minimise the effects of

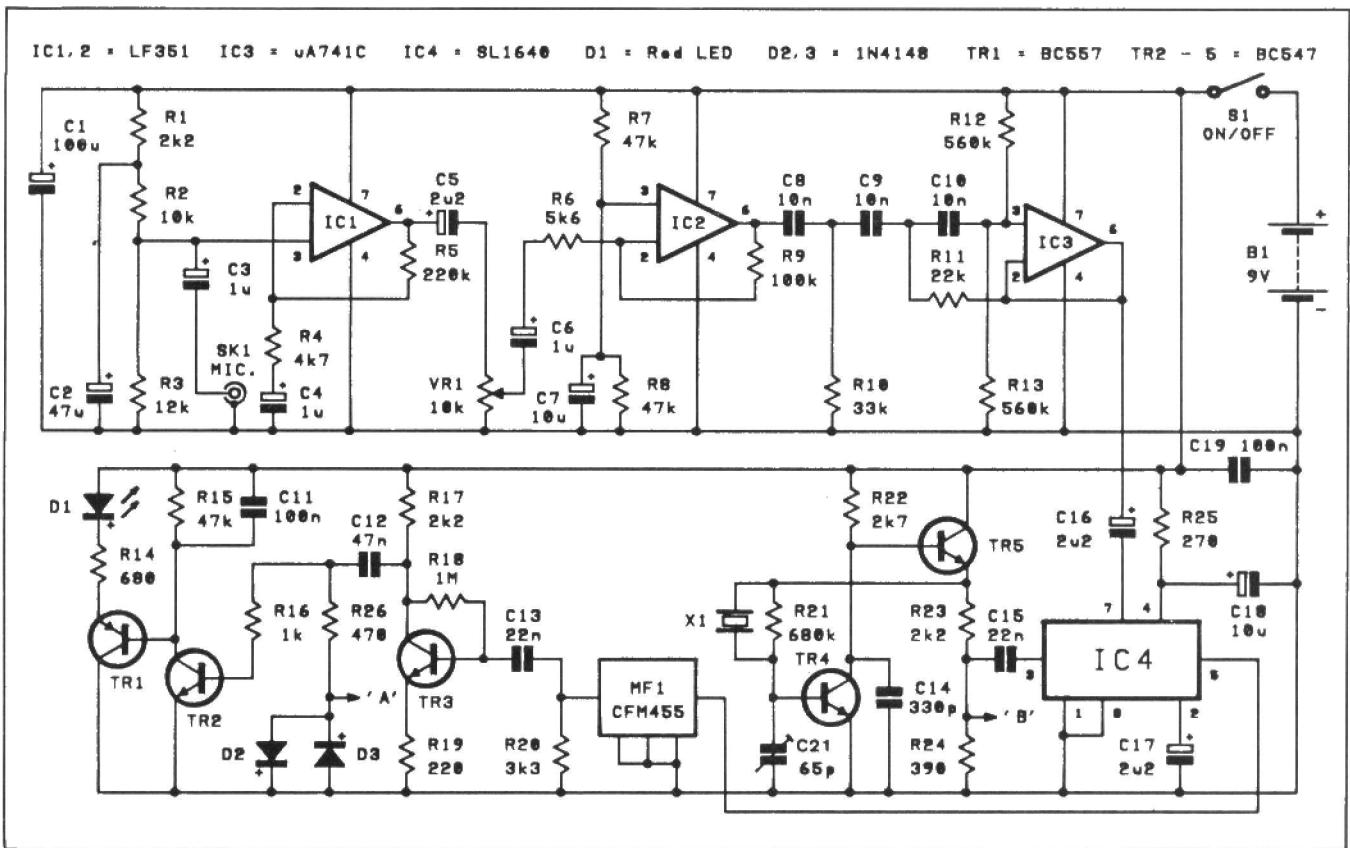
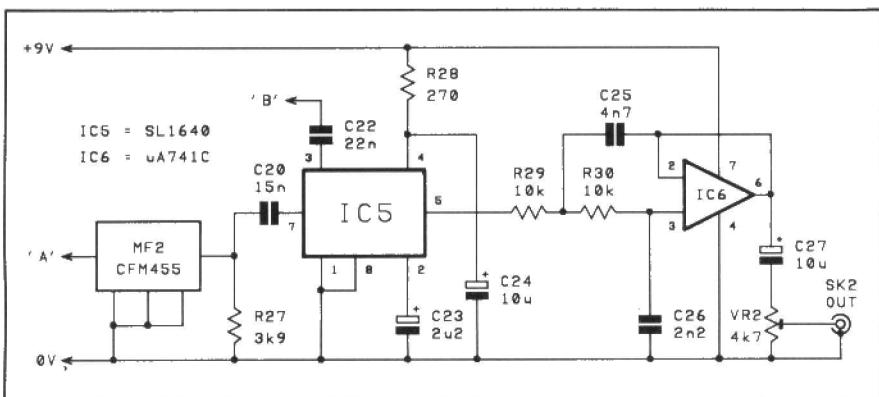


Fig.4. The AF speech processor main circuit diagram



oscillator that was used during the generation of the ssb signal. The difference frequency furnishes the original audio frequencies, and a lowpass filter removes the radio frequency sum signal to leave just this required audio signal.

PRACTICAL CIRCUIT

The main circuit diagram for the rf speech processor appears in Fig.4, but the demodulator circuit is shown separately in Fig.5.

IC1 and IC2 are used in the microphone preamplifier, and these are conventional non-inverting and inverting mode circuits respectively. These give a combined voltage gain of just under 60dB, and this is sufficient to permit operation with low impedance dynamic microphones. The unit also seems to work well with medium or high impedance dynamic microphones, or any types which have similar output characteris-

tics. It will not work properly with crystal microphones. VR1 is the microphone gain control. The highpass filter is a third order (18dB per octave) active type which has IC3 as the buffer amplifier.

IC4 is the balanced modulator, and this is a device specifically designed for ssb modulation/demodulation applications. The SL1640 is not a particularly cheap device, but it has the advantages of not requiring any balance adjustments, and it has good distortion performance. The cost of the unit could be reduced somewhat by using simple diode modulator and demodulator circuits, but when I tried this it resulted in relatively high distortion levels. This is unacceptable in a unit which is intended to give minimal distortion levels, and so the SL1640 was used in the final design. This device requires a nominal 6 volt supply, and this is derived from the 9 volt battery supply using dropper resistor R25 and decoupling capacitor C18.

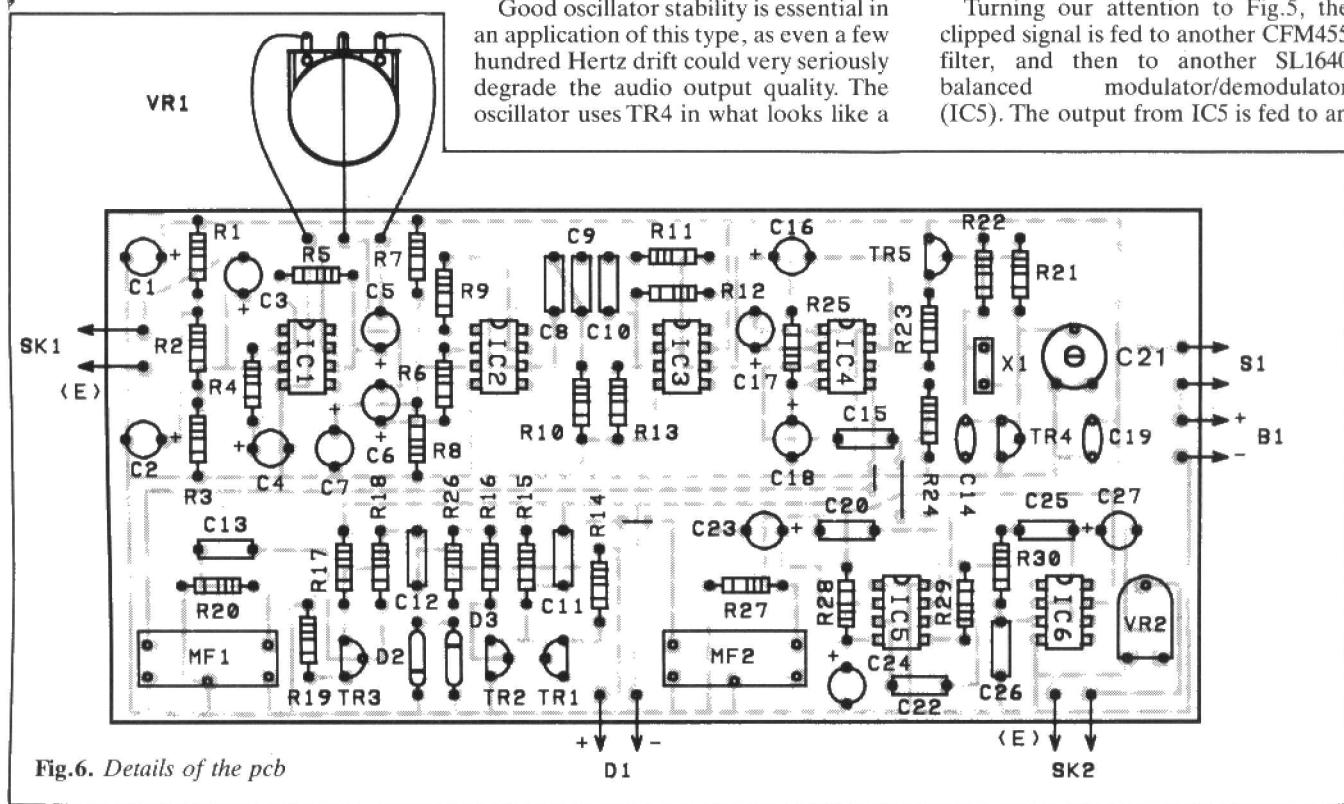
Good oscillator stability is essential in an application of this type, as even a few hundred Hertz drift could very seriously degrade the audio output quality. The oscillator uses TR4 in what looks like a

conventional crystal controlled circuit, with TR5 acting as an emitter follower buffer stage at the output. The only non-standard aspect of this circuit is that X1 is not an ordinary crystal, but is actually a ceramic resonator. This does not give the same degree of stability as a "real crystal", but it seems to be much better than using an L-C oscillator. There certainly seem to be no drift problems with the prototype, and quite large variations in the supply voltage fail to induce any significant shift in frequency. C21 is used to trim the oscillator to a suitable operating frequency.

MF1 is the first ssb filter. It has a minimum -6dB bandwidth of 2.6kHz, and a maximum -50dB bandwidth of 8kHz. This is not particularly good in comparison to other ssb filters, but it is very good for a filter in this price range. It should be borne in mind that the above are worst case figures, and that a typical filter will provide -6dB and -50dB bandwidths of more like 3kHz and 6kHz respectively. The degree of selectivity provided by the CFM455 certainly seems to be adequate for good performance in the present application.

TR3 is a common emitter amplifier which boosts the filtered signal by about 20dB (ten times) before it is fed to a diode clipping circuit (D2 and D3). These provide hard clipping at approximately plus and minus 0.65 volts. If the clipping level is reached, TR2 is biased into conduction on the peaks of positive half cycles. C11 smooths the voltage pulses this produces across collector load resistor R15, and this signal drives led indicator D1 by way of emitter follower buffer stage TR1.

Turning our attention to Fig.5, the clipped signal is fed to another CFM455 filter, and then to another SL1640 balanced modulator/demodulator (IC5). The output from IC5 is fed to an



RF SPEECH PROCESSOR

active second order (12dB per octave) lowpass filter based on IC6. VR2 is the output level control, and this enables the output to be adjusted from zero up to about 1 volt peak to peak. Where possible it is probably best to use a fairly high output level, but in most cases the unit will probably have to be used to drive a microphone input. VR2 is then backed off to give an output level that is comparable to the signal level provided by the microphone.

CONSTRUCTION

Results with the original prototype seemed to be sufficiently encouraging to justify building up the design as a fully fledged constructional project. Construction of the unit is reasonably straightforward using the printed circuit design of Fig.6. Unusually, none of the integrated circuits are mos types, but I used holders for all of them anyway. I would strongly recommend the use of holders for IC4 and IC5 at least, as the SL1640s are not a matter of a few pence each.

A plastic/metal instrument case which measures about 171 by 145 by 56 millimetres makes a good housing for this project. This will just about accommodate all the components including a reasonably high capacity 9 volt battery. The current consumption of the circuit is quite high at approximately 30 milliamps, and six HP7 size cells in a plastic holder represent what is probably the smallest battery that will economically power the unit. Connection to the battery holder of this type is via an ordinary PP3 style connector. I used 3.5 millimetre jack sockets at the input and output of the unit, but these could obviously be changed for any other type that would be more convenient with your particular set up.

ADJUSTMENT AND RESULTS

With the aid of suitable test gear C21 can be used to trim the carrier oscillator to precisely the optimum frequency. Presumably few constructors will have access to this type of equipment, but this does not really matter as it is probably best to adjust the unit subjectively for the best results anyway. The method I found best was to feed the output of a broadcast receiver into the microphone input of the processor via an attenuator (a 220k series resistor will suffice). Choose a program source that provides speech rather than music, and with VR2 fully advanced monitor the output signal using a crystal earphone, headphones, or an amplifier plus loudspeaker. Advance VR1 far enough to cause D1 to flash brightly on each burst of speech signal, and then adjust C21 for optimum output quality.

You will probably find that there is a small range of settings at which a very muffled and distorted output is

RESISTORS

R1,R17,R23	2k2 (3 off)
R2,R29,R30	10k (3 off)
R3	12k
R4	4k7
R5	220k
R6	5k6
R7,R8,R15	47k (3 off)
R9	100k
R10	33k
R11	22k
R12,R13	560k (2 off)
R14	680
R16	1k
R18	1M
R19	220
R20	3k3
R21	680k
R22	2k7
R24	390
R25,R28	270 (2 off)
R26	470
R27	3k9
All 1/4 watt 5% carbon	

POTENTIOMETERS

VR1	10k log
VR2	4k7 sub-min hor preset

CAPACITORS

C1	100μ 10V radial elect
C2	47μ 25V radial elect
C3,C4,C6	1μ 63V radial elect (3 off)
C5,C16,C17	
C23	2μ 263V radial elect (4 off)
C7,C18,C24,	
C27	10μ 25V radial elect (4 off)
C8,C9,C10	10n polyester layer (3 off)
C11	100n polyester layer
C12	47n polyester layer
C13,C15,C22	22n polyester layer (3 off)
C14	330p ceramic plate
C19	100n ceramic
C20	15n polyester layer
C21	5.5/65p trimmer
C25	4n7 polyester layer
C26	2n2 polyester layer

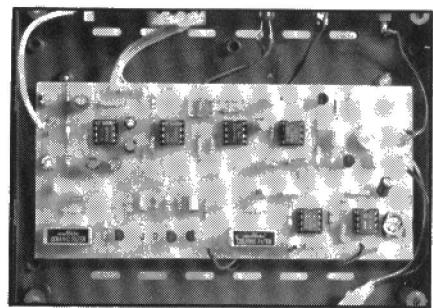
SEMICONDUCTORS

IC1,IC2	LF351 (2 off)
IC3,IC6	uA741C (2 off)
IC4,IC5	SL1640 (2 off)
TR1	BC557
TR2,TR3,	
TR4,TR5	BC547 (4 off)
D1	Red panel led
D2,D3	1N4148 (2 off)

MISCELLANEOUS

S1	s.p.s.t. sub-min toggle
SK1,SK2	3.5mm jack socket (2 off)
B1	9 volt (e.g. 6 × HP7 in holder)
X1	455kHz ceramic resonator (CSB455E)
MF1,MF2	CFM455JI (2 off)

Printed circuit board, battery connector, control knob, case about 171 × 145 × 56mm, 8 pin dip ic holder (6 off), wire, stand-offs, solder, etc.



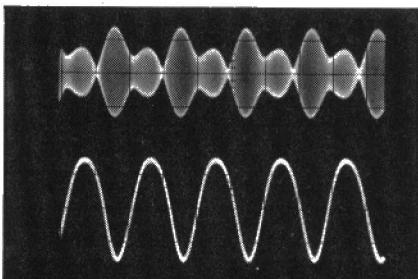
Interior view of RF speech processor assembly

obtained. This is with the carrier frequency well towards the middle of the filters' passbands. Adjusting C21 either side of this setting should give a much clearer signal. It is probably best to offset it in the direction that gives a higher capacity, as this will give better reliability from the oscillator. If the oscillator sometimes seems reluctant to start, try making C14 somewhat higher in value, or use a very high gain device (such as a BC549C) in the TR4 position.

Results from the unit seem to be quite good, and are better than those from any audio speech processor I have tried. There is noticeable distortion on heavily clipped low frequency test signals, but at medium and high frequencies (where the filters are more effective) a very clean output signal is obtained. Rf speech processors can achieve distortion levels of under 1% with 12dB of limiting. I do not think that this design achieves such a high standard of performance, but the distortion level is only about three times this figure. The output signal is free from any obvious distortion unless the microphone gain control is advanced beyond 12dB of limiting. With a lot of limiting a large rise in distortion is only to be expected, as the audio stages and the modulator will be overloaded.

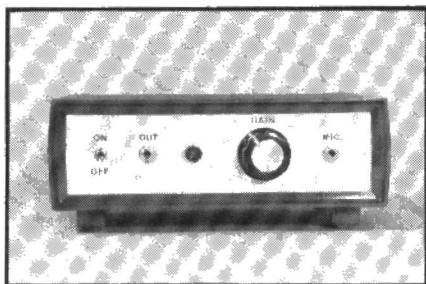
IMPROVEMENTS

The design offers a respectable level of performance in its current form, but it could be improved. The obvious



A heavily clipped RF signal and the resultant (800Hz) audio output. The output shows some distortion and a slight lack of symmetry, but is very good by speech processor standards

The SL1640, CFM455JI, and CSB455E are available from Cirkit Holdings plc.



upgrade is to use higher quality filters. This should give lower distortion levels, particularly at low input frequencies, but it could easily result in the overall cost of the unit being more than doubled. The improvement in performance might

not justify the extra expense, and this is something that would only be worthwhile if optimum performance at any price was all that mattered.

Audio speech processors often have an automatic level control somewhere ahead of the clipping circuit. This ensures that the signal is always at the optimum clipping level, and it can be very effective when added to an audio processor. An alternative is to have some form of Vu meter to indicate the degree of clipping so that it can be accurately set manually.

Experimenting with circuits of both types did not really give a significant improvement in performance. With an

rf speech processor a slightly excessive amount of clipping is far from disastrous as far as the audio output quality is concerned. Accordingly, the effect of maintaining a highly accurate clipping level is hardly noticeable.

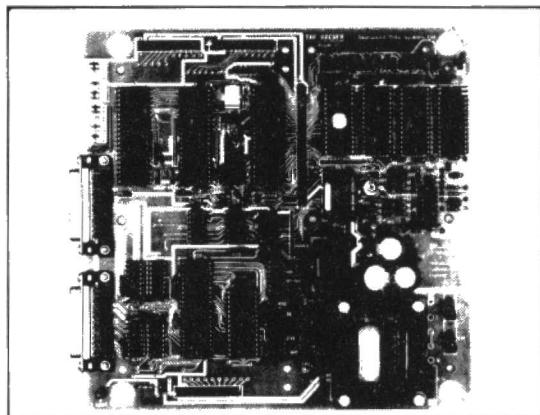
What would probably be a worthwhile line of investigation would be to try generating the ssb signal using some form of phasing type ssb generator. If a suitable simple and inexpensive circuit could be devised it would almost certainly give a worthwhile improvement in performance. A phasing type generator should give a high degree of sideband suppression over the full audio input frequency range.

PE

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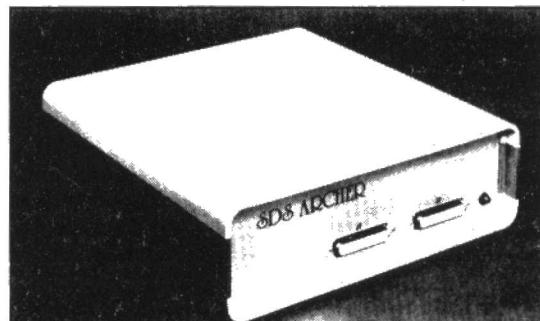
- ★ Top quality board with 4 parallel and 2 serial ports, counter-timers, power-fail interrupt, watchdog timer, EPROM & battery backed RAM.
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DAT EVOLUTION

BY BARRY FOX

THE TECHNOLOGY AND THE POLITICS

The news of an audio cassette tape format which would equal compact discs in sound quality caused a furor in the recording industry. The public, press and politicians were bombarded with evidence that a new age of piracy was about to dawn. Is it? Why all the fuss?

Digital audio tape, or DAT, has been on sale in Japan for over a year now, since March 1987 – but it is not selling well. The new super format should have long since been available in the UK and America but an extraordinary controversy several times delayed a launch in the West – although by Christmas several hundred people had bought “grey imports”. There has never been another consumer electronics product which has generated so much contention and been so widely misunderstood.

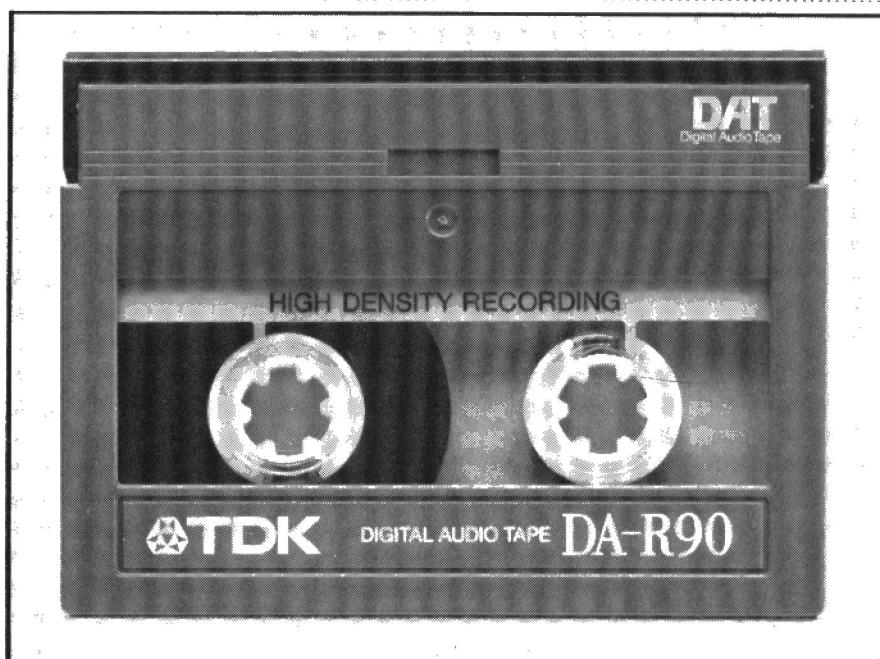
Dat records digital audio of compact disc quality on a credit card size tape cassette. It was ready for launch at the Japan Audio Fair in the autumn of 1985. But pressure from the retailers trade association NEBA (Nippon Electronic Big-Stores Association) put Dat on hold. The dealers were worried that Dat would confuse the public, and slow down sales of cd and 8mm video.

The launch was rescheduled for a year later, at the October 1986 Tokyo show. But that too was shelved because the record industry took up cudgels. Dat finally reached Japanese shops in March 1987. But because the record industry refused to make pre-recorded software available, and because there was so much uncertainty over the format's future prospects, sales have been slow. The uncertainty follows from a debate on Dat which the record industry has pushed onto the US government and European Parliament. Dat has now been shown many times at public and trade exhibitions in Europe and the US, but always without a firm price and date for availability.

INDUSTRY RELUCTANCE

The record industry does not like the idea of a tape which can make direct digital dubs from the digital output of a compact disc player; even an analogue dub for cd will be of far better quality than a conventional cassette copy.

But already the Dat recorders on sale to the public have an anti-copy circuit built in which refuses to record an incoming digital data stream if it includes a stop-copy flag bit. There is provision



in the cd data stream for just such a flag, although some record companies do not bother to insert it. Also domestic Dat machines record only at a sampling rate of 48kHz or 32kHz so that they cannot make direct digital dubs of the 44.1kHz signal coming from a cd. The domestic Dat player will however play back at cd sampling rate, for the reproduction of prerecorded music Dat cassettes – when the record industry decides to treat Dat as a potential source of revenue, rather than an enemy to be destroyed at all costs!

Much of the current controversy stems from a plea by the music industry's trade body, the IFPI, (International Federation of Phonogram and Videogram Producers) for laws to prevent Dat recorder's from making analogue copies of music discs. CBS has developed a system called Copycode for putting an inaudible code on a commercial recording. This code is a notch in the sound waveform which is reputedly undetectable to the human ear, difficult to identify by analysis and even more difficult to obliterate. If a Dat player is fitted with a code-sensing circuit, it will refuse to copy a coded recording.

Although all this sounds fine in theory, there is a yawning gap between theory and practice. Existing analogue recordings are not coded and it will take years before the record companies get sufficiently organised to doctor every new release. They don't even have an agreed policy on putting anti-copy flags into cd issues. Also the record companies have shot themselves in the foot. They have succeeded in persuading many governments round the world that there should be a levy or tax on blank tape. If blank tape is taxed to permit home taping, why should the Japanese hardware manufacturers build circuitry into their machines to prevent home taping? Already the British government has abandoned its previously-firm plans for a tape tax.

For a year the IFPI and CBS lobbied behind closed doors without demonstrating Copycode. Audio engineers pointed out that the identification notch on which the system relies (a deep suck out from the music at 2.84kHz) would be audible. When the system was finally demonstrated, the notch was duly heard. This produced a wholly predictable welter of criticism and the National

Bureau of Standards in America is now conducting independent tests. All this delays the full scale launch of Dat.

When the history books are written Copycode will be seen simply as a system designed to hamper and hinder Dat – and that it most certainly has already done, even if in the end no laws are passed to compel the electronics industry to build Copycode sensors into Dat recorders. The red herring debate over Copycode, conducted mainly by people who are totally at sea with the technology involved, diverts attention from the hard facts about Dat.

For instance although Dat will always be more expensive than cd (around 50%, or more likely 100%), because of the intricate mechanical moving parts, the price will eventually come down from current levels of around £1000. But this will not happen until cd has become too deeply rooted to unseat. All the signs are that cd and Dat will eventually co-exist, like the lp and Philips compact cassette.

JAPANESE MOTIVATIONS

To understand why all this should be, it makes sense to look first at the broader area of tape as a storage medium.

Magnetic recording was invented in Europe, improved in the US and plagiarised by the Far East. Dat could let the Japanese tape industry do to the West what the Japanese electronics companies have already done to the audio and tv industries in Europe and the US.

The Japanese do not want Dat simply because it offers longer playing time and higher audio fidelity. They want it because the new system will clear their few remaining debts to the West. For twenty years the Japanese electronics industry has been obliged to make recorders and recording tape which follow the compact cassette standard set in Europe by Philips. Virtually all audio cassette tapes and recorders cut the hiss inherent in analogue tape by using Dolby or dbx noise reduction. Both systems were invented in the US.

Dat has been developed in Japan. Only Philips of Holland (and perhaps Thompson of France) will be able to contribute to the new technology. Understandably Philips is in no hurry to kill off its existing analogue tape standard and risk undermining its royalty revenue from cd.

Dat relies on high signal packing density. It builds from the developments which made 8mm video a saleable commodity. A single video cassette, smaller than an audio cassette and loaded with tape 8mm wide, can record three hours of analogue colour tv pictures and digital stereo sound, or 18 hours of digital stereo without pictures. Other video formats (VHS and Beta) use half inch or 12.5 mm tape in much

much larger cassettes which do not (yet) record digital audio as well as analogue pictures.

TAPE TECHNOLOGY

Recording technology is a compromise mix of chemistry, electronics, physics and kitchen cooker. A tape-coating material which is ideal in one respect is often unusable because of other characteristics; it may record a signal well but not hold it reliably for subsequent playback. Production engineers at tape plants must continually juggle the production process parameters to compensate for slight differences in the raw materials which they buy in bulk from the chemical industry. If they do not do this there is no hope of producing a tape which consistently meets the paper specification. The text book definitions of magnetic parameters are of little practical use in understanding tape technology.

Packing density on a moving magnetic medium depends on the number of signal transitions which the medium can resolve per unit of length. For analogue recording, the signal transitions are discrete fluctuations in the signal waveform. For digital recording the transitions are pulses which signify ones or zeros. The number of signal transitions which can be recorded and recaptured depends on the speed at which the medium is moving and size of the individual magnetic particles in its surface layer or coating. These particles change magnetic polarity when they record a signal. Just as light cannot resolve detail smaller than its wavelength, so magnetic particles cannot resolve a recorded signal smaller than their physical size.

HEAD SPEEDS

One full wave, or cycle of an analogue waveform, is captured by two magnetic fields – one for the positive swing of the wave, one for the negative. If a tape is running past the recording head speed at 4.75 cms a second, as for conventional audio cassette tape, a musical note of 15kHz frequency will have a wavelength of 3 micrometres, or microns. Good quality audio cassette tape can cope with this requirement. But if an attempt is made to halve the tape speed, the recorded wavelength falls to 1.5 micrometres which is impractical. On the other hand, if the tape speed is doubled, the recorded wavelength for a 15kHz tone rises to a robust 6 micrometres.

A digital signal can have twice the clock or pulse rate of a sine wave ie a 5 MHz analogue channel can handle a digital pulse train running at 10 Megabits per second. Each bit is equivalent to the full sine wave. Using a technique called duobinary coding, the data rate can be

doubled again; each pulse can be switched between two levels. But then noise can cause errors because the decoder has to recognise not just pulses but levels of pulse.

INHERENT NOISE

All tape systems suffer from noise. The individual particles also create random mush beneath the signal. This is either heard as background hiss in an analogue sound recording or it confuses a digital decoder into reading ones for zeros or vice-versa. The noise gets worse if the particles are of uneven size. Modern tapes have acicular or needle-shaped particles of very consistent size.

Particle size and shape is only part of the picture. The tape surface must be smooth or it will wear away the recording heads. Most magnetic recording materials have a physical characteristic similar to fine sand-paper. But if the surface is too smooth, friction will make the tape cling to metal guide rollers; this is 'stiction'.

Some materials appear ideal but lose their magnetism when subjected to physical pressure, for instance if it passes many times through a recorder. This is called the magnetostrictive effect. Heat can also kill the signal. As tapes are used in hot climates and closed cars this is a very real consideration.

COERCIVITY

Coercivity and remanence are frequently quoted in publicity literature, but less frequently understood. Coercivity is a measure of the magnetic flux intensity required to return a magnetic material from saturation to zero. In practice this is usually the same as the flux intensity or magnetic field strength needed to record a magnetic signal onto tape. So a high coercivity tape needs a greater flux intensity. Coercivity has increased considerably through the history of magnetic tape. It has risen as particle size falls, and recorded wavelength gets shorter. High density recording needs a high coercivity coating, because the small particles needed to resolve the small signal transitions will de-magnetize each other if they are of low coercivity. Coercivity is measured in oersteds.

Remanence is closely tied to retentivity. It is a measure, in flux lines or gauss, of residual magnetism. This is the amount of magnetic signal retained in the tape coating after it has left the influencing field of the recording head. So it tells how much signal the playback head will find to read.

The very high packing density needed for 8mm video and Dat follows from the development of very high coercivity coatings. Surprisingly, politics is involved as well as technology and chemistry.

HISTORICAL PERSPECTIVES

The first magnetic material, used by Valdemar Poulsen for his Telegraphone in 1900, was steel strip. There was no coating but recording capacity and coercivity were limited by the crystalline structure of the metal material, to around 100 oersteds with magnetic spheres 2 or 3 micrometres in diameter. The shortest recorded wavelength was 1 mm. Louis Blattner produced an improved version which the BBC used to record programmes until the end of World War II. By then BASF and AEG in Germany had taken up an idea patented by Fritz Pfleumer of Dresden in 1928. Pfleumer suggested coating paper strip or tape with a thin layer of magnetic iron dust.

In 1932 BASF (then part of the infamous IG Farben chemical group which fuelled the German war machine) tried using acetyl cellulose instead of pure metal. The pure iron dust was prone to explode during manufacture or rust in use. The oxide particles were still 2 or 3 micrometre spheres. Recorded wavelength was 100 micrometres, ten times shorter than for Poulsen's wire.

Gamma ferric oxide, which has now familiar brown colour, became the standard material for coating tape. It is still used for cheap domestic tape. Thanks to work by 3M and Armour Research in the US after the war, the oxide particles are acicular or needle-shaped with a length of less than 1 micrometre. Coercivity or iron oxide is still limited to around 400 oersted. A fevered search, in the 60s, for higher coercivity coatings of stable character created a split in the industry between Japan and the West which has had far-reaching, and arguably devastating, effects on Europe.

CHROME DIOXIDE

In the US, E.I. Du Pont de Nemours, now known as Du Pont, filed a string of patent applications on a magnetic oxide of chromium with acicular particle structure. Chromium dioxide offers coercivities of up to 700 oersted, and is stable under heat and pressure. In 1966 Philips realised that the new material could work wonders for its audio cassette system. Later chrome did the same for early video.

Du Pont granted licences under its chrome patents to BASF, Philips, Ampex, Memorex, 3M, Agfa and Sony. BASF is the only company granted a full licence to manufacture chrome dioxide powder from raw chemicals. All the other licensees are authorized only to buy chrome powder from Du Pont and use it for coating tape. Because Sony was the only Japanese company licensed under the Du Pont patents, the rest of the Japanese tape industry began a crash research programme to find an alter-

native material. By 1973, just two years after BASF started an almost religious commitment to chrome technology, TDK in Japan developed Avilyn.

Small quantities of cobalt are absorbed into the surface of acicular gamma ferric oxide. The result is a stable magnetic material with coercivities even higher than chromium dioxide. The entire Japanese tape industry, now including Sony, is as heavily committed to cobalt-modified ferric oxide chemistry as BASF is to chrome. Pseudochrome tapes, as they are popularly known, are now used as a benchmark by the Japanese hardware manufacturers. Japanese tape recorders are designed to produce best results when used with pseudochrome tapes, and these are of course available mainly from Japanese tape companies.

The merits and demerits of genuine chrome and pseudochrome, for instance whether chrome is abrasive and wears recording heads badly, are endlessly debated. Already the arguments are academic. Both chrome and pseudochromes are now at the end of their developmental life. Coercivity cannot reach the very high levels, around 1500 oersted, needed for 8mm video and Dat. Minimum recorded wavelengths is limited to 1 micrometre. Both 8mm video and Dat need shorter wavelengths and a completely new type of tape. Ironically it represents a full circle turn back to Poulsen and his pure metal tape for the 1900 Telegraphone.

MANUFACTURING TECHNIQUES

There are two ways of making metal tape. A plastic base film is coated with acicular particles of pure metal, or the metal is evaporated in a vacuum and deposited on a chilled base. Tape manufacturers have learned over the last ten years how to make metal powder, mp tape, but are still unable to mass-produce metal evaporated, me. Paradoxically hardware manufacturers have had to struggle with the problems of recording onto mp tape, and find me much easier to work with.

Metal powder tape is already on sale for analogue audio recording. All the tape so far available for the new 8mm video format is mp. Dat cassettes use mp tape. The production bugs were ironed out in the 70s when Philips and 3M found a way of making acicular iron particles by the chemical reduction of iron oxide or sulphate in the presence of a catalyst. To stop the pure metal rusting to non-magnetic oxide in a humid atmosphere, the particles are sealed in a resin binder.

Recording on tape of such high coercivity (1,000 oersted or more) creates very real problems. It requires such a powerful magnetic field from the recording head to impress a signal on the tape that the recording head can

easily saturate with its own flux before the tape is affected. Until 1980 heads were made of iron alloy or ferrite, which have a low saturation point. A new alloy called Sendust has twice the flux capacity of ferrite. It is an alloy of iron, aluminium and silicon, named after the Sendai region of Japan where it was developed. The material is formed by compressing dust into the precision shape of a recording head. But Sendust is brittle and tends to rust; if it is mixed with chrome to prevent corrosion, this spoils its magnetic characteristic. For its 8mm video recorders and 1500 oersted 8mm video tape Sony makes the main body of the recording head from tough ferrite, with a sputtered layer of Sendust at the tip where the magnetic flux is concentrated. The quality of pictures available from 8mm video was still improving almost daily, when 8 mm was first launched and Sony tinkered daily with the head tip technology and tape coating chemistry.

The alternative approach is to make the recording head from amorphous metal. The raw material is heated to its melting point and then rapidly cooled, at around one million degrees centigrade per second. This "freezes" the metal in 1000th of a second and adopts a non-crystalline structure. Amorphous metals are corrosion resistant, hard and have a very high saturation point. But amorphous heads are difficult to make and still expensive.

PACKING DENSITY

Metal tape has broken the micrometre barrier. Signal packing on the domestic 8mm format is now the densest of any recorded medium, in use for any purpose. Recorded wavelength is around 0.7 micron. One minute of colour tv signals and digital stereo sound occupies just 48 square centimetres of tape area. By comparison one minute's recording on the VHS format occupies 180 square centimetres. The first video recorders used by the broadcast industry thirty years ago needed 12,000 square centimetres of tape for a minute of picture and sound; and the pictures were black and white and the sound mono only.

It was Matsushita engineers in Japan who in 1979 finally succeeded in vacuum-depositing a thin film of cobalt-nickel alloy on a plastics based film. EMI then did research work on this technology in Britain on behalf of all the European tape manufacturers. The metal layer can capture very short recorded wavelengths, because it is non-crystalline. It is so thin, less than 0.5 micrometre thick and one tenth the thickness of conventional magnetic coatings, that the metal becomes transparent. Because it is so thin a cassette can hold twice as much me tape as conventional tape. So storage

capacity and playing time are doubled. Coercivity is as high as for mp tape, but because the recording flux need penetrate only a fraction a micrometre, conventional heads can cope. The thin coating cannot store low frequencies, so it is no use for analogue hifi recording. But video and digital signals rely on high frequency fm waves or pulse codes, so it is ideal for future projects. The only snag is in making it.

VACUUM DEPOSITION

Here Matsushita's research in me technology is already paying off. The company heavily patented the production process and has now licensed BASF of West Germany, 3M of the US and most Japanese companies to make me tape. Each company has its own highly secret know-how. When I visited TDK in Japan, two years ago, it was the first time a Japanese company had showed how it made samples of ME tape.

A vacuum chamber, around 10 metres tall, opens like a clam shell to receive a "jumbo" roll of plastics base film, 27.5 cm wide. The clam is closed and pumped to a high vacuum. A high intensity electron beam scans a block of alloy. This melts to create a metal vapour which fills the vacuum chamber while the base film spools through at up to 10 kilometres per hour. The trick is to get the boiling metal vapour to bond with the plastic without destroying it. A high voltage erodes the plastic to create a key for the metal vapour as it settles on the film. The film moves over a rotating metal drum which is continually filled with liquid freon at -100 degrees C. The hidden snag, which engineers only talk about when asked, is that the boiling metal vapour fills the chamber and deposits on the walls as well as the tape. So far it takes up to an hour of work with a hammer and chisel to chip it free.

TDK could make a roll of plastic, 7 micrometres thick, with a pure metal layer 0.1 micrometre thick. But it took an hour to coat the roll, an hour to pump the vacuum and an hour to clean the chamber. One jumbo roll yields only around 900 cassettes. "Compared with metal powder tape" says Hideki Hotsuki, General Manager at TDK's research and development centre "we have to admit that cost-to-performance ratios are not so good". One estimate is that ME will cost up to ten times as much as metal powder tape which is itself at least twice the price of oxide tape. To gain production experience Matsushita has for several years been selling ME tape in Japan, under the trademark Angrom, for low fi audio dictation use.

DAT DEVELOPMENT

Dat, digital audio tape is a direct development from 8mm technology. All

the major electronics manufacturers in Japan, together with European firms Philips, BASF and Thomson, agreed a standard for Dat. More accurately they agreed two standards; one for stationary or S-Dat and one for rotary or R-Dat.

S-Dat is a development from IBM computer technology. In an IBM mainframe computer, of the type used by banks and big business, half inch chrome dioxide tape runs fast past a stationary recording head. The tape width is divided into 18 parallel tracks. Two computer words or 8-bit bytes, plus 2 parity bits for error correction, are spread out across the tape.

The data rate on and off IBM 3480 tape is 3 Mbyte/second. Packing density is 38000 bytes per inch or 7480 bytes per cm because two 8-bit bytes (plus 2 parity bits) are spread out across the tape. This puts the length of each bit along the tape at 1.34 micrometres.

R-Dat is spin-off from helical scan video recording where the tape moves slowly and the recording heads move rapidly to scan narrow tracks obliquely across the tape width.

The tape for both S-Dat and R-Dat is the same width as conventional audio cassette tape, 3.81mm; i.e half the width of 8mm video tape. But the cassettes are smaller than audio or 8mm video cassettes. Tape coercivity is 1,500 oersted. The coating may be either mp, or me when available. The technology is tricky. Even BASF buys its Dat cassettes from Japan.

TAPE RATES

In an S-Dat recorder the tape runs at 4.7cms/second past a stationary recording head which is divided into 22 separate sections. Each records its own individual track along the tape. The sound to be recorded is converted into 16 bit digital code words and the word bits spread out across the separate tracks as well as long it. By this parallel processing technique, slow running tape handles a data transmission rate of 2.4 megabits/second.

In an R-Dat machine the 16 bit code words are fed serially to a recording head which is mounted on a rotating drum. In its most basic format, the drum diameter is 30mm and the tape runs at 8.15mm/second along a 90 degree section of the drum circumference which rotates at 2000 rpm to give a relative tape-to-head speed is 3.13 metres/second. The helical tracks recorded across the tape are only 15 micrometres wide, which is narrower than any video format. Data transmission rate is almost the same as for S-Dat, 2.46 magabits per second. Recorded wavelength is 0.7 micrometres.

The rotating head mechanism for R-DAT requires precision engineering, but all the mass production design work has

already been done by the video factories. Although apparently simpler to engineer, S-Dat relies on very accurate division of the recording head into its 22 separate tracks. The only reliable way to achieve this is with microchip production techniques, by photo etching a thin metal film. If the tape weaves, the head sections read the wrong tracks.

So far there are no S-Dat machines available; it has proved too difficult to make the multi-gap recording heads with sufficient accuracy. S-Dat may never be launched.

R-DAT STANDARDS

There are in fact six different standards or modes for R-Dat recording.

As already mentioned, although all Dat recorders will play back at 44.1kHz, domestic models will record only at 48kHz or 32kHz sampling rates - to allow direct digital recording from radio or satellite broadcasts but stop direct digital dubbing from cds. The coding standards are either 16 bit linear coding or 12 bit non linear.

The 32kHz format will either offer four channels of simultaneous recording, like a four track multi-channel machine, or two channels at half the tape speed (and half the drum speed) to double the playing time per cassette from 2 hours to 4 hours. So far the JVC machine (and Grundig's oem clone) is the only one to offer half speed recording and playback. The current 2/4 hour maximum playing time will extend further when thinner, metal evaporated, tapes are available.

There is incidentally, a very narrow analogue track along the edge of the DAT tape. No-one is quite sure what it is for. "It seems to be simply a security blanket", one engineer told me.

The final, sixth mode, runs the tape 50% faster and is designed for use with pre-recorded cassettes which have been duplicated at high speed by thermal or magnetic image contact transfer copying.

COPYING TECHNIQUES

In a thermal copier two tapes are sandwiched together, one master tape and one blank, and heated so that the magnetic image is transferred. For magnetic transfer a similar sandwich is blitzed with a strong magnetic bias.

Sony has already developed a magnetic copier, which can work at over 300 times the speed needed to make copies in the conventional manner - by copying music from one Dat recorder to another.

A very high coercivity metal powder tape is used as the transfer master. A mirror image of the original recording is copied onto this tape at a real time speed of 12.23 mm/second. The copy tape is

coated with barium ferrite, which has a lower coercivity than metal. As a rule of the mirror master must have around three times the coercivity of the blank copy tape.

The copy made by sandwich transfer is a mirror copy of the mirror master and thus a right-way-round copy. But it plays at 12.23 mm/second. This 50% increase in running speed reduces playing time by 50%, but increases data capacity. The extra capacity is used to store extra error correction bits. This is intended to protect the system against digital errors introduced when they were copied by sandwiching.

The general public will not need to know anything about these six different Dat modes. Machines will automatically recognise the mode of any tape, and switch accordingly for correct replay.

VIDEO TAPE

Samsung, of Korea, has built a prototype video camcorder which uses a Dat audio cassette instead of a conventional VHS or 8mm video cassette. Technically this is no real problem. The frequency of the square wave pulse digital audio signal recorded on the tape is a staggering 9.04MHz, which is almost exactly twice the highest frequency recorded on conventional domestic video tape. The system is unlikely, however, to find backing from Japan where the electronics industry is already committed to VHS, Beta and 8mm video.

Critics of Dat have theorised that because the system relies on head-to-tape contact, the tape will have limited life before dropouts make it unusable. Certainly conventional video tapes for recordings have limited life. Video film libraries often find that tapes wear out after only around fifty rentals. But Sony claims that because the tape tension for Dat is so low, measured in grammes only, and because the recording head is barely skimming the surface of the tape, Dat recordings will run at least 1,000 times, and probably 10,000 times, before there is more signal loss than the error correction codes can repair.

Although the head-drum in the first machines on sale in Japan is 30mm in diameter and rotates at 2,000rpm, this is not a fixed parameter. All that is fixed is the writing speed, 3.133 metres per second. Already Matsushita (Panasonic) has announced a second generation Dat portable which uses a half size (15mm) drum round which the tape is wrapped 180 degrees instead of 90 degrees to give recordings which are compatible with full size machines.

DOMESTIC DAT

At the Berlin Funnkausstellung, held last August, Sony finally bit the bullet

and announced that it would start selling domestic digital audio tape recorder in Britain in October, for around £1,300. The Sony move was clearly intended to pre-empt the legislation with which the record companies were seeking to stymie Dat for domestic use. Sony set the price of its Dat recorder high (around £300 more than in Japan) but there was still such an outcry from the record industry that the launch was quietly shelved again. JVC then looked likely to launch its two speed Dat deck. The situation now changes almost daily.

Whatever happens over Dat as a domestic audio system, Sony has for many years looked on Dat as the ideal bulk carrier for computer data and text - like a recordable erasable cd rom, with slower access times but much, much cheaper.

DAT DATA STORE

A joint project on Dat as a data store between Sony and Hewlett Packard has the smell of success, because it was the cooperation of HP and Sony which made the 9cm magnetic floppy disk a new standard for microcomputers - which even IBM has now adopted.

For data Dat, blocks of 8 bit bytes are recorded. This data streams on, and off, the tape at the very high rate of 170 kilobytes/s which is around 600 Mbytes/hour. So a two hour Dat cassette, costing under £10, can store 1.2 gigabytes of data. This makes the tiny cassette equivalent to more than 1000 conventional floppy disks!

In addition to the error correction already provided by the Dat format for hi fi, HP and Sony have agreed a second level of error correction which gives an extra 10% redundancy. This ensures that data recordings are virtually free from any errors.

The Dat data storage deck will be made the same as a conventional floppy disk drive, so that it can be built into the body of an IBM PC or clone. The cassette can either be used as a back up store for all the data recorded on Winchester or floppy disks (so that if the disks are damaged or lost the user can immediately restore all data), or the computer can read large chunks of data

from tape and load it into the computer's ram for rapid access.

A 2 hour Dat cassette, storing 1.2 gigabytes of data, can be fully re-wound in 41 seconds. The average search time between sections of data along the tape is less than 20 seconds. Conventional tape stores have much smaller capacity and take minutes to spool through. HP and Sony plan to start volume production of Dat data drives by the end of 1988.

HIGHER DENSITY

Already tape engineers are looking past 8mm and DAT towards even higher recording densities. Theoretically the shortest wavelength which can be recorded is around 0.25 micrometres. The practical limit is probably 0.5 micrometres. Even the slightest movement of the tape away from the head causes so much signal loss at these wavelengths that the system mutes. The BBC has found that a fingerprint on the tape can cause separation from the head of 2.5 micrometres which, for a recorded wavelength of 1.25 micrometres, causes 100 dB loss. This is equivalent to reducing the signal voltage by a factor of 100 000.

If the magnetic particles are made too small, so that they approach the size of a single magnetic domain or component of the material chemistry, they simply refuse to record any signal at all. The next stage of development will be vertical or perpendicular recording. Whereas the particles of a conventional magnetic coating lie parallel to the surface, in a vertical recording medium they stand upright, at right angles to the surface. The analogy is with the Isle of Wight, which can hold the world's population, provided that they are all standing. The tendency for the particles to demagnetise each other is significantly reduced and recording density increases by a factor of at least ten.

It would be neatly ironical if, by scuppering the launch of Dat, the record industry were to buy the electronics industry enough time to develop a vertical recording format which increases recording time by a factor of ten.

PE



Some recording techniques are more of a consumer product than others

TEACHER COUNTER

PART TWO BY TIM PIKE

Concluding the last in a series of projects aimed at students of GCSE Electronics preparing for project work for examination this year.

Here endeth the GCSE lesson, with a simple project to count up the marks

FIG. 18 shows a block diagram for a manually clocked 0 to 99 counter running two seven segment display units, each with its own driving stage.

(Some of you may also be interested to know that there are special counter-driver chips available that will directly count and drive several segment displays simultaneously. One such was used in the Event Counter in PE July 87. Ed)

If you are keen to test out the logic analysis developed above then perhaps you could run one display from this logic array and the second one from a commercial display driving chip. Remember that you will need to invert the outputs (a-g) before presenting them to a common anode display. Fig.19 gives the circuit diagram for a 0 to 99 counter driving into two seven segment displays. The logic array replaces one driving stage if you intend trying this out.

I will leave it to the interested and able reader to design the printed circuit layout for the logic array. This is considerably more complex than the average GCSE candidate would be expected to tackle, but if you have

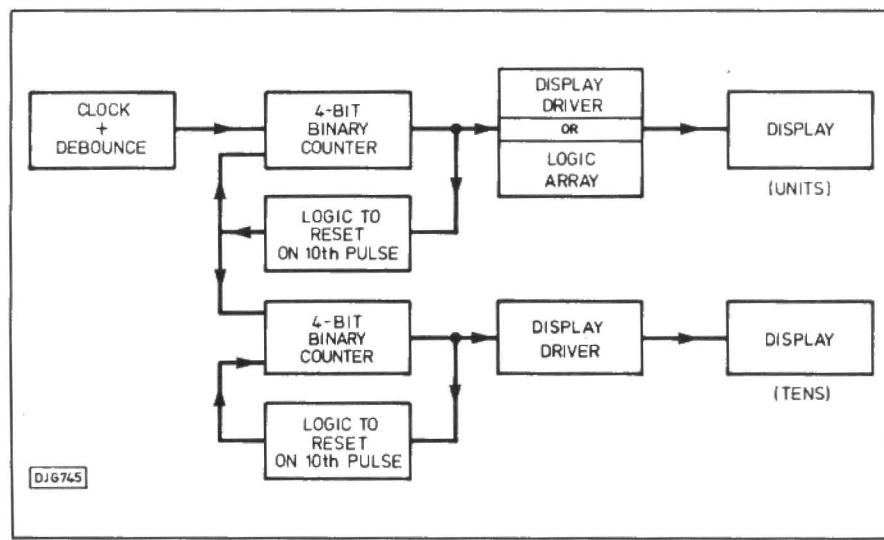


Fig.18. Block diagram for the 0 to 99 manually clocked counter

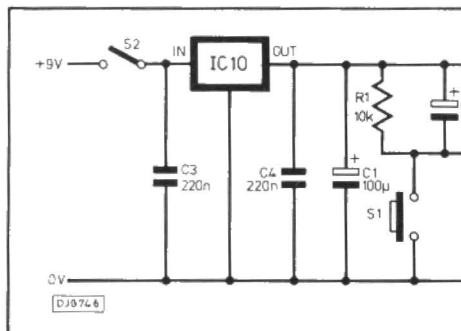
divided the basic PCB design into two which makes it easier to sort out the interconnections on a single-sided board. It also allows the use of a smaller container.

Remember the general advice which

I have given before and try to work tidily and logically. Test each part of the circuit carefully and you will surely complete an interesting and successful project.

Good luck and I hope that you have enjoyed the series.

PE



followed all the theory you should be able to handle this problem.

Fig.20 gives one possible layout for the event counter based on the use of the display driver chips. The layout includes the option of replacing one of the driving stages by the logic array as developed earlier in the article. I would strongly recommend that the logic array be kept to a separate PCB and that it is thoroughly tested before incorporating it into the rest of the project. I have

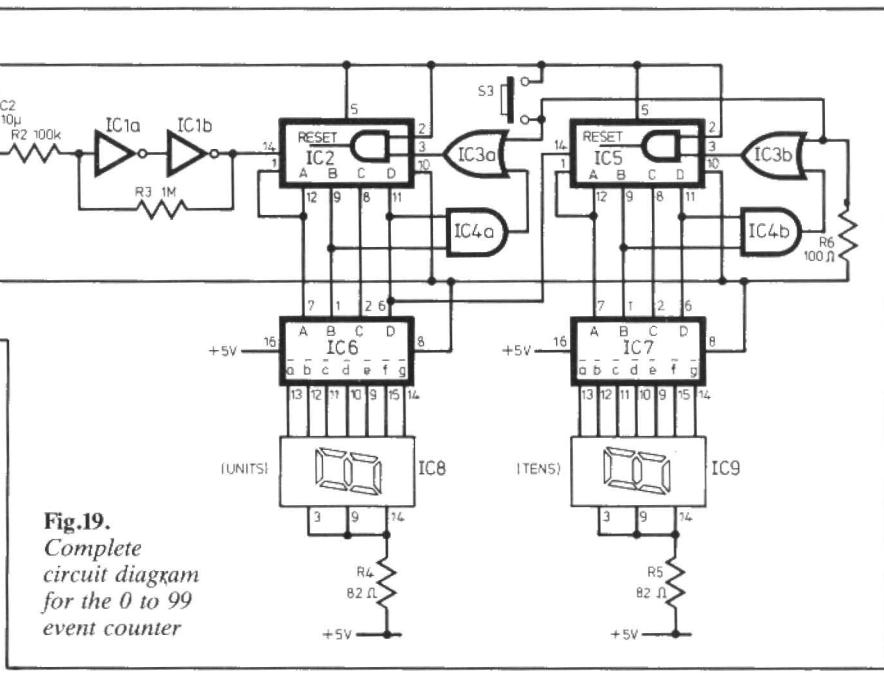


Fig.19.
Complete
circuit diagram
for the 0 to 99
event counter

COMPONENTS**RESISTORS**

R1 10k
 R2 100k
 R3 1M
 R4,R5 82 (2 off)
 R6 100
 All $\frac{1}{4}W = \pm 5\%$ carbon.

CAPACITORS

C1 100 μ F 10V electrolytic
 C2 10 μ F 10V electrolytic
 C3,C4 220nF polyester or ceramic (2 off)

SEMICONDUCTORS

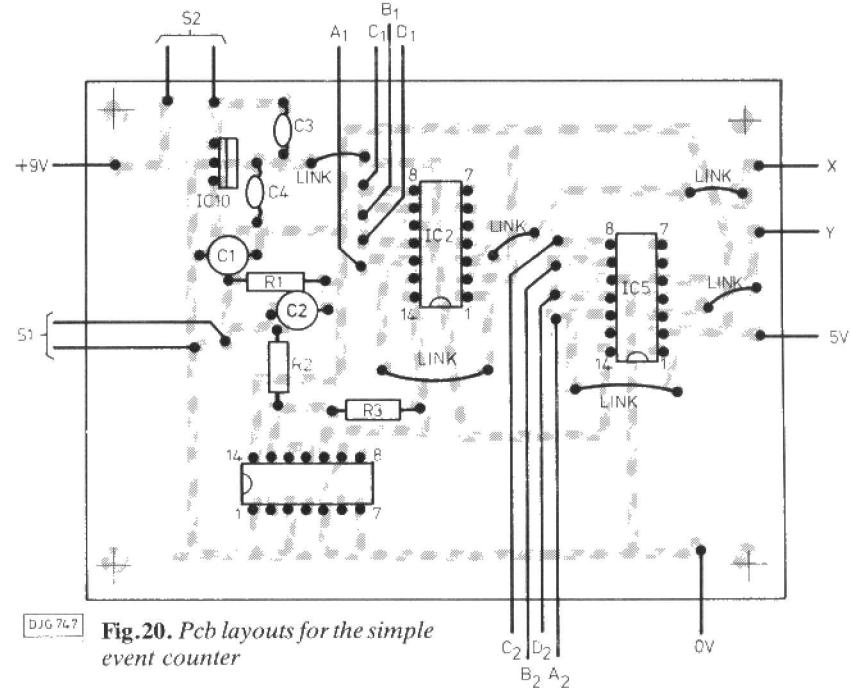
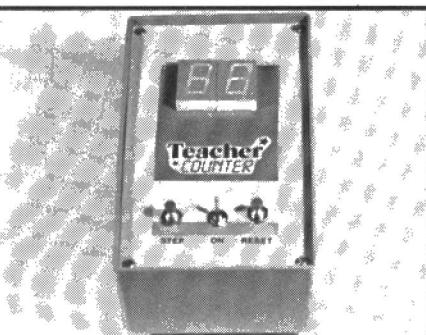
IC1 4069UB cmos (hex inverting buffers)
 IC2,IC5 7493 ttl (4 bit binary counters) (2 off)
 IC3 7432 ttl (quad 2 1/P OR)
 IC4 7408 ttl (quad 2 1/P AND)
 IC6,IC7 7447 ttl (display drivers) (2 off)
 IC8,IC9 Seven segment displays (common anode type) (2 off)
 IC10 7805 (+5V regulator)

MISCELLANEOUS

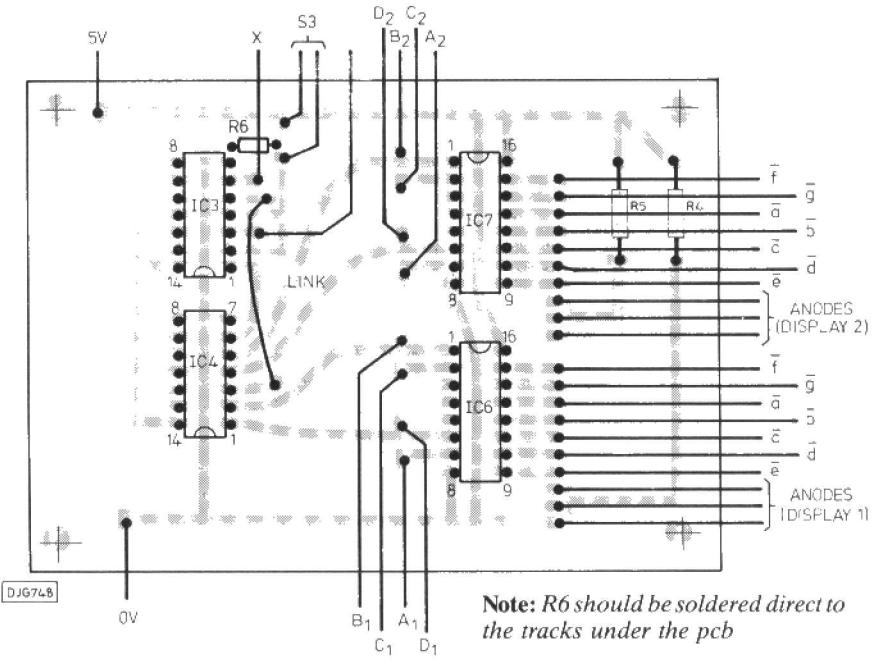
S1,S3 spst push to make switch (2 off)
 S2 spst toggle switch
 IC sockets (14 and 16 pin dIL), printed circuit boards, suitable container, wire, solder, 9V battery or power supply.

CONSTRUCTOR'S NOTE:

The printed circuit boards are available through the PE PCB service.



DIG747
Fig.20. Pcb layouts for the simple event counter



DIG748
Note: R6 should be soldered direct to the tracks under the pcb

TRACK MEMORY

Barry Fox's article on Dat evolution prompts nostalgic memories. I recall that when I first started working at the Elstree film studios in 1957, magnetic sound track recording was not yet in widespread use. My first experience of it was, I believe, in 1958 when I was working, as a junior editing assistant, on *Indiscreet*, starring Ingrid Bergman and Cary Grant.

Although some sound tracks were initially recorded on quarter inch tape, frequently at a speed of 15 or 30 inches per second, the tracks were re-recorded onto 35mm wide magnetic film, the same gauge as the picture. Zonal was the manufacturer whose stock was in most common use, though I believe that

both Kodak and 3M also manufactured it. Two versions of the 35mm width were in general use, one was fully coated with the magnetic material spread right across the film area. This was most generally used for master sound track recording, and was capable of having several tracks recorded on it side by side.

The other version was 'striped', and was normally the stock used for editing. It consisted of two magnetic stripes, one of one quarter inch width running down one side, upon which the sound was carried. A second stripe ran down the opposite side, of a much narrower width, and was simply there to counter balance the physical thickness of the

first stripe. The running speed was that used for the picture projection, 90 feet per minute or 18 inches per second, allowing excellent frequency response. Eventually equivalent magnetic tracks became available for 16mm film, though the speed was lower, of (I think) 36 feet per minute, or a little over 7 ips, with an equivalent bandwidth reduction.

The bandwidth of film sound tracks shown in cinemas was lower still since the magnetic tracks were generally re-recorded as photographic images that were printed alongside the picture.

It was probably about 1960 that I first saw a magnetically recorded video image, also on 35mm width film.

Ed.

HAS ANYBODY HERE SEEN DAT?

BY WAYNE GREEN

WINTER CONSUMER ELECTRONICS SHOW — LAS VEGAS

Dr Wayne Green is the renowned US author, publisher and founder of over 50 computer and technology magazines, including Byte and Microcomputing. He is currently a vice-presidential candidate in the US primary elections.

For the third CES in a row the big question was: where's DAT? Digital Audio Tape, where *ARE* you?

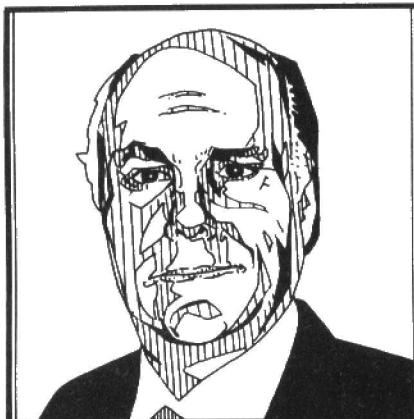
Despite the prolific propaganda from the RIAA (Recording Industry Association of America), which has received disgustingly enthusiastic media support, the "Will Congress Kill Dat?" workshop at CES — for the third time — made it very clear that despite some close committee votes on the subject, congress has no intention of being suckered by the music industry into protective anti-technology legislation.

DAT PROTECTION

The Dat vs protection situation seems to be in grid-lock, with the Japanese afraid to upset congress by shipping dat systems to the US — fearing not only a bad reaction to the RIAA propaganda barrage, but also concerned that this could result in further Japan-bashing. They realise that many Americans have the Japan vs US situation in perspective, putting the blame for the loss of one industry after another to Japan on America, not Japan. But that obviously won't stop congressional demagogues from taking advantage of their uniformed constituents' emotional reactions. Senator Gephardt, sadly, seems to be a typical demagogue of this ilk.

Some major record companies have apparently been convinced that the Dat ogre will inevitably result in the unrestricted copying of compact discs, thereby virtually destroying their new industry. Unlike cassette copies of LPs, Dat copies of CDs will be perfect copies, since the process is digital. (*Barry Fox looks further at this situation in his "Dat Evolution" article, Ed.*)

The congressional workshop panel said still again, hey, the RIAA put on



the pressure and swore on stacks of bibles that the music industry would be completely demolished if we didn't stop cassette. The result, instead has been the biggest bonanza in record industry history, with 60% of all music today being sold on cassettes.

Then we heard the same cry again when the movie industry assured us that it would be destroyed by the video recorder. Stop technology, was the plea. Congress somehow managed not to do this. The result, again, was a bonanza — with video tapes being the biggest money-maker in movie history.

So here are the cries of "wolf" again. Will congress try to stop technology? Not likely, despite heroic efforts by Congressman Waxman (Hollywood) and Senator Gore (Nashville). Gore's willingness to try and stop a technology that people obviously want has not helped his flagging presidential aspirations.

COMPROMISE PROPOSAL

In an effort to resolve the Dat problems, as the moderator of a Dat

workshop at CES, I offered a compromise which seemed to satisfy all sides of the controversy. Hopefully this will help get Dat started in the US.

My proposal was for Dat systems to be imported and sold without restrictions in the US — systems with no protective circuits whatever — systems with the capability of directly copying compact discs. Then, after two years, the RIAA would fund an independent study to measure the actual loss to the music industry — if any. This study would check on teenage, home, business and commercial pirate copying. If the study shows a significant loss to the music industry, then the Dat industry would support legislation to levy a royalty on blank Dat tape which would be used to reimburse the music industry for its losses.

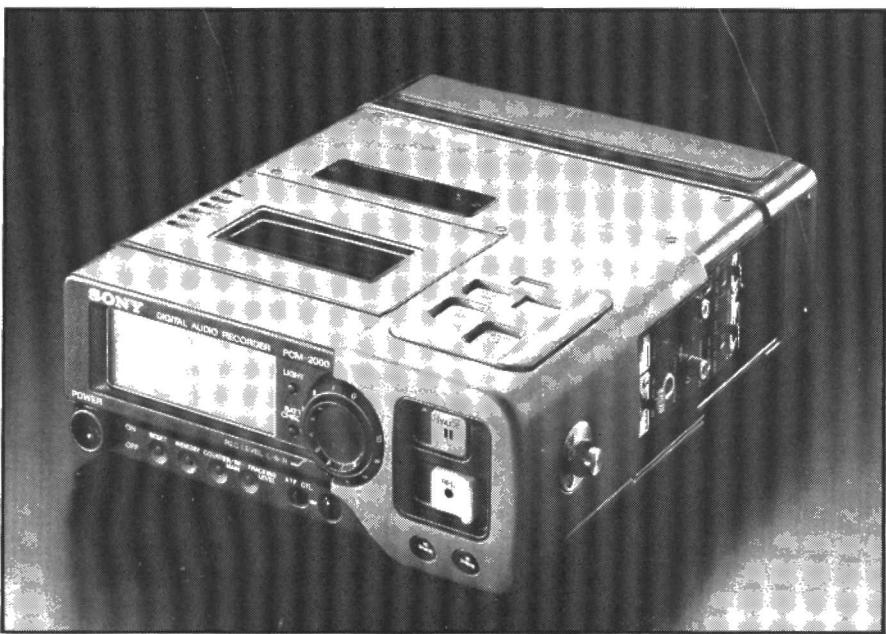
No one I've spoken to in the Dat industry has any reservations about this since they are convinced that the end result of Dat will be even more music sales rather than less. Indeed, several labels (such as Capriccio) have already started shipping Dat pre-recorded tapes.

The Dat manufacturers point out that Dat systems are already being sold in Western Europe and Asia, with not one case of commercial pirating yet to surface.

PRACTICAL POTENTIAL

My own enthusiasm for the medium is not fuelled by any great hopes for it for music, but more for its potential for the computer industry. Indeed, I expect the computer applications will quickly dwarf the music uses for Dat.

I've had a Dat recorder for a year now and found very few practical uses for it. In talking with other people who have gone to the trouble to buy Dat recorders from Japan or buy them through a grey



Sony digital audio recorder type PCM-2000

market source, I find their experience has been very similar to mine.

Yes, I did have fun making live digital recordings of the Temple Town Band and then making analog cassette copies for them. It made fantastic cassettes. But other than that and checking to see if I could hear the difference between a cd direct and a Dat copy made via an analog route (no detectable difference, thank you), I've rarely used the recorder.

As a publisher I was really looking forward to CBS using their proposed notch copy-code system. I planned on publishing a list of the butchered cds, expecting this would cut their sales seriously and get 'em off that ridiculous kick. Alas, Sony bought CBS records and, despite some officials disclaimers that this would in no way change things, there were enough knowing winks and elbow nudges to make it obvious that notching cds was a dead issue. Darn.

So we have congress awaiting a report from the National Bureau of Standards on how noticeable the copy-code notch is — apparently not realising that events have overtaken the project, making it no longer relevant.

BROADER SCENE

Dat was the big news at CES. Other than that there was a profusion of new compact disc players with ever more features to excite fanatical audio hobbyists. Super-vhs products were everywhere. 3D video is getting better, but still hasn't shown up in any practical form so far. High definition tv (hdtv) was shown — marvellous, but they're still horsing around with different formats. Most require much greater bandwidths than regular tv — some are

compatible with current tvs, some aren't. Hdtv will be along.

Three-D movies never got anywhere — 3D 35mm slides never did either — so one has to wonder about the life expectancy of 3D video. 3D has been with us for over a hundred years, going back to stereoptican slides, which were popular in American parlours in the 1880s. Thirty years ago the Kodak Retina cameras had an accessory stereo lens which split the 35mm image and provided exceptionally good stereo slides. The problem was that they had to be viewed with a special personal viewer. Nothing has yet been devised to make projection practical. How many stereo adapters do you see today for 35mm? None I know of. So much for progress.

Compact Disc-Video (cdv), which was such a big deal at the June Summer CES in Chicago, was almost invisible this time. No software. It appears that the Japanese have laboured mightily and come forth with a technology that's still looking for an application. Five minutes of video and 20 minutes of digital sound on a cd? Maybe mtv? No, that seems to be a fading fad. Condensed operas maybe? Ho hum.

FLAGGING INTEREST

Though the official head count for CES was 103,000 — about the same as last year — for some reason most of the exhibitors I talked with felt the attendance was way down. Unlike last year, even when the crowds were at their worst, I had no problem in speeding from one end of the huge show to the other to keep appointments.

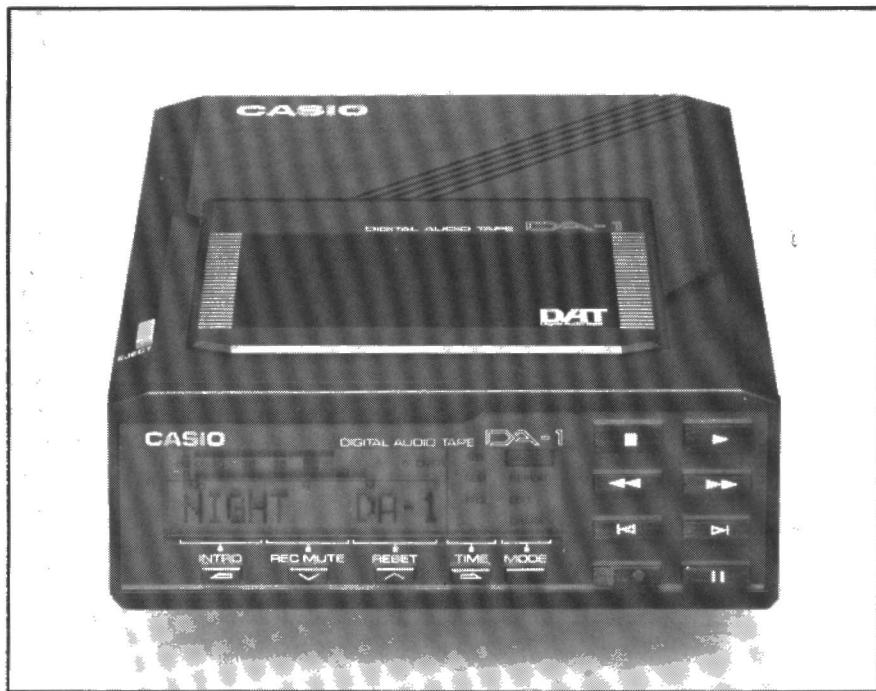
The CES decision to stop the smaller record companies from selling cds at bargain promotional prices during the show kept most of them away — disappointing many attendees ... and me.

The home computer exhibitors were very few this time, reflecting the market shift to business sales and more specialised shows such as for desktop publishing.

The show ran for four days, but the last two days seemed to be more devoted to watching football than business. It was often difficult to get through the excited groups clustered around the many projection tv sets. The huge convention centre echoed with cheers on every touchdown.

By Sunday evening I think the Las Vegas blackjack dealers, showgirls, cabbies and car rental firms were ready for a well-earned rest.

PE



Right: Casio digital audio recorder type DA-1

FIRST MAKE TRANSPARENT COPY

(We regret that we cannot supply transparent copies of PCB track layouts.)

Have a normal photocopy made, ensuring good dense black image. Spray ISOdraft Transparentiser onto copy in accordance with supplied instructions. ISOdraft is available from Cannon & Wrin, 68 High Street, Chislehurst, Kent. Tel: 01-467 0935.

NEXT PRINT ONTO PCB

Place positive transparency onto photosensitised copper clad fibre glass, cover with glass to ensure full contact. Expose to Ultraviolet light for several minutes (experiment to find correct time – depends on UV intensity).

Develop PCB in Sodium Hydroxide (available from chemists) until clean track image is seen, wash in warm running water. Etch in hot Ferric Chloride, frequently withdrawing PCB to allow exposure to air. Wash PCB in running water, dry, and drill holes, normally using a 1mm drill bit.

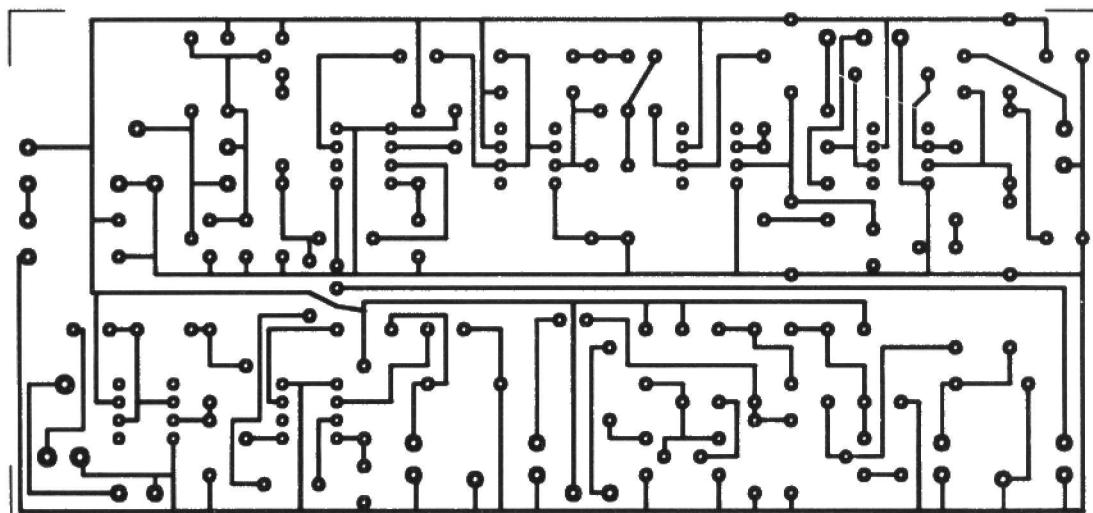
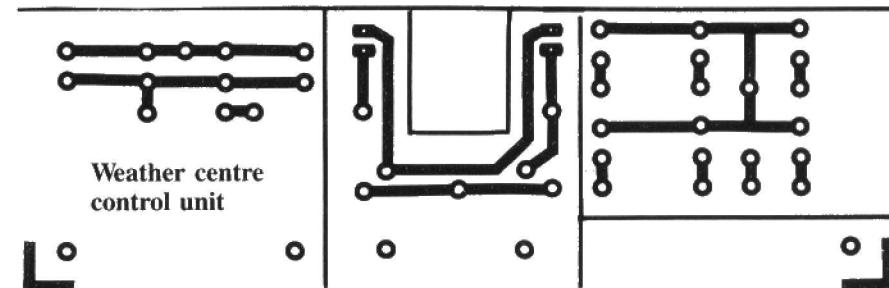
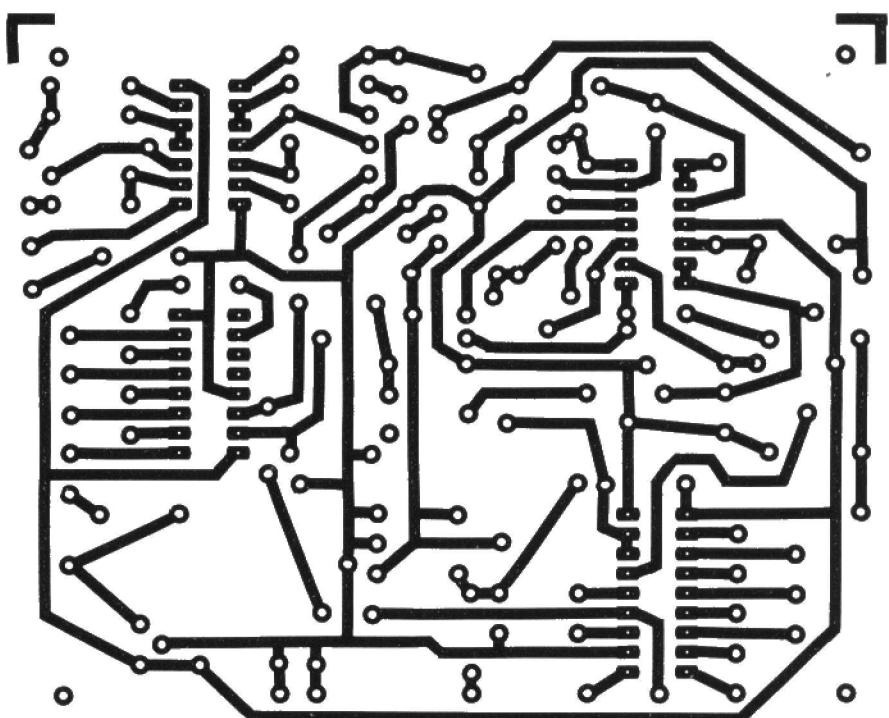
(PCB materials and chemicals are available from several sources – study advertisements.)

* CAUTION – ENSURE THAT UV LIGHT DOES NOT SHINE INTO YOUR EYES. PROTECT HANDS WITH RUBBER GLOVES WHEN USING CHEMICALS.

ALTERNATIVE METHOD

Buy your PCB ready made through the PE PCB SERVICE, most are usually available – see page 60.

HOW TO USE THESE TRACKS



PE172

EXPERIMENTAL WEATHER CENTRE

PART THREE BY JOHN BECKER

SOFT WEATHER

In part 3 of the PE weather centre, we give a new meaning to micro climates but putting the centre (not, alas, the weather) under computer control if so desired. Something to pass a rainy afternoon...

You've no doubt got nearly everything shown so far put together, and are anxious to complete it. So let's complete the digital conversion stage and move on to the final constructional details, and the setting up.

DIGITAL CONVERSION

To send the detected dc data levels to the computer, they must first be converted to a digital representation. This is carried out by IC12, an analogue to digital converter, in Fig.21. I used the ZN448, but the ZN447 or ZN449 will do equally well.

The dc data comes to IC12 from IC10b, and via VR9. This pot is used to preset the maximum voltage input that will produce an equivalent digital output of 100 decimal. Upon receipt of the trigger pulse from ATN, IC12 begins its conversion run. The rate of conversion is set by C26. This controls an oscillator within IC12, and the conversion run takes just 9 clock cycles. At the end of the conversion, a positive going Ready signal is sent back to the computer along the DAV line. On receipt of this level change, the computer can read the data present on DA0 to DA6, carry out any desired correction to it, and display the result on the screen.

Synchronisation is achieved by monitoring the output of IC10d, presented via R74 along line DA7. When this line is high, the computer can reset its programmed cycle, so allocating subsequent data to the correct detector function. Not much to it really, is there?

Just a couple of other points to mention about IC12. The tristate output capability of the chip is not used here, and the data is always present on its output, irrespective of the count status. Secondly, the negative voltage required at its pin 5 is taken from D19 and C23 via R77; it does not need accurate regulation.

MULTIPLEX ALIGNMENT

Even if a computer is ultimately to control the monitoring, start off setting up by means of the built in automatic

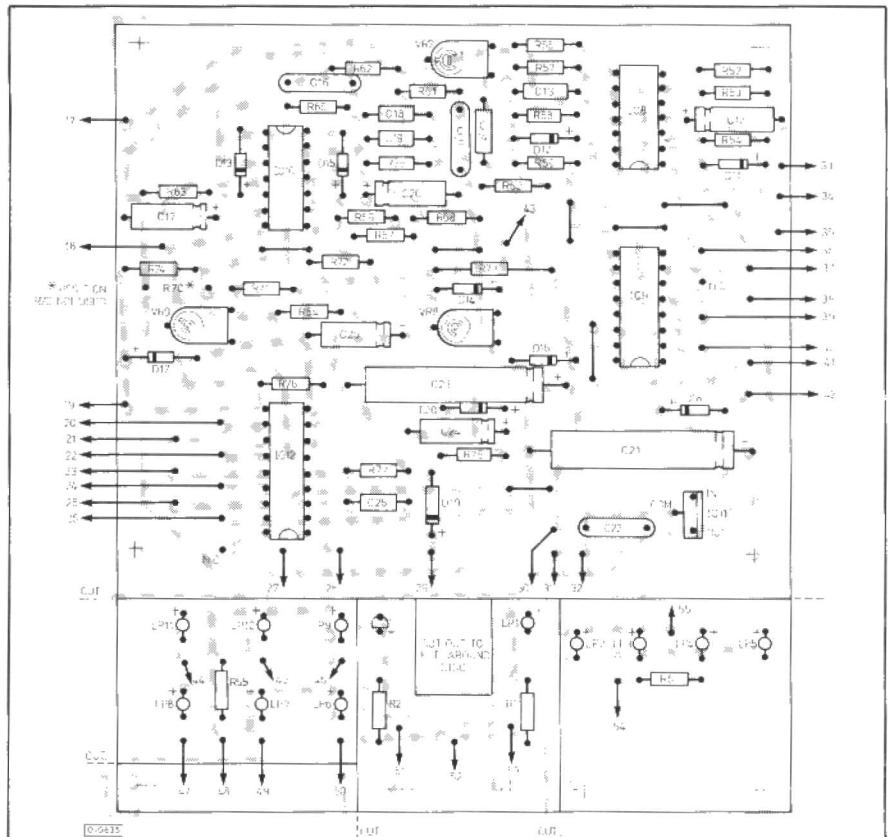


Fig.20. Printed circuit board for the controller

control. First, switch off S1, and switch S2 to Auto. A voltmeter should now prove that the output of IC8c is slowly oscillating. This should also be evident from the sequential glowing of the leds LP6 to LP11. A fluctuation of the meter should occur at the output of IC8f, though probably not reaching any higher than half line voltage due to the hf frequency content.

Next, monitor the junction of D9 and C10, adjusting the hf frequency control preset VR7 until the best swing is observed. Then check that this swing triggers the comparator IC1d up and down. Monitoring pins 9, 11 and 12 of IC6 will confirm by their swing that the address counter is functional. Now monitor pin 3 of IC5 at which point voltage levels reflecting the detector

voltage states should be seen stepping through in sequence. Similar voltage levels should be apparent at the output of IC10b.

When the address counter opens IC5 to allow the sync frequency from IC4b to pass through, switch S1 to Hold, so keeping the gate open at this address. Monitor the junction of R67 and C20, and adjust VR6 until the voltage reaches a maximum level. Switch off S1, and observe that the voltage at C20 swings up and down, and that the comparator IC10d triggers up and down in sympathy. It should then be obvious that the counter IC9 is being reset after every eighth pulse.

Now the computer can be coupled in and its control operation checked, having first switched S2 to ATN.

WEATHER — HARDWARE

Further information is given in the drawings and text.

35mm translucent film canister, cable ties, wind coding discs (1 of each), gantry and brackets, connecting wire, 3-core connecting cable, aluminium sheet, fibreglass sheet, feet (4 off), grommets (3 off), misc nuts, bolts and washers, stereo jack plugs (5 off), rotary pots (2 off — to be vandalised for their parts!), spindle coupling, steel rod 0.25 in dia, empty gallon oil can, boxes to suit (2 off), light weight aluminium tubing, pcb support clips, flange plates 1.5 in dia (3 off).

WIND SPEED

A couple of factors come into play in assessing wind speed detector output results. The first factor is the radius length to the centre of the cone. With the measurements shown in the drawings, one can readily calculate the number of pulses that will be generated for a particular rotation rate. There are 18 holes, so if the arm rotates once a second, the pulse frequency will be 18Hz. The distance travelled by the centre of the cone for one revolution is naturally $2 \times \pi \times R$. In this case the rotation speed is approximately two mph. A pulse rate of 50Hz works out at about five mph.

This figure of 50Hz makes rotation speed calibration nice and easy. The secondary winding of transformer T1 has a 50Hz output at about 9 volts. If we rectify this as shown in Fig.22 and roughly halve its level by using a couple of 10k resistors, the output is suitable for triggering the input to the windspeed detector, at IC3a-b. With this known triggering rate, the meter deflection point can be noted, as can the computer decimal conversion. A conversion factor can be put into the program to show the correct decimal readout for given frequency counts.

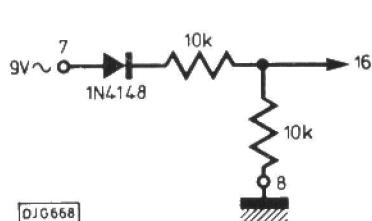


Fig.22. Wind speed calibration circuit

ROTATIONAL EFFICIENCY

The other factor to be considered regarding wind speed is the efficiency of the wind cones on the rotating arm. Although the wind may be travelling at say 10 mph, the conversion efficiency of the rotor may only be half that and the

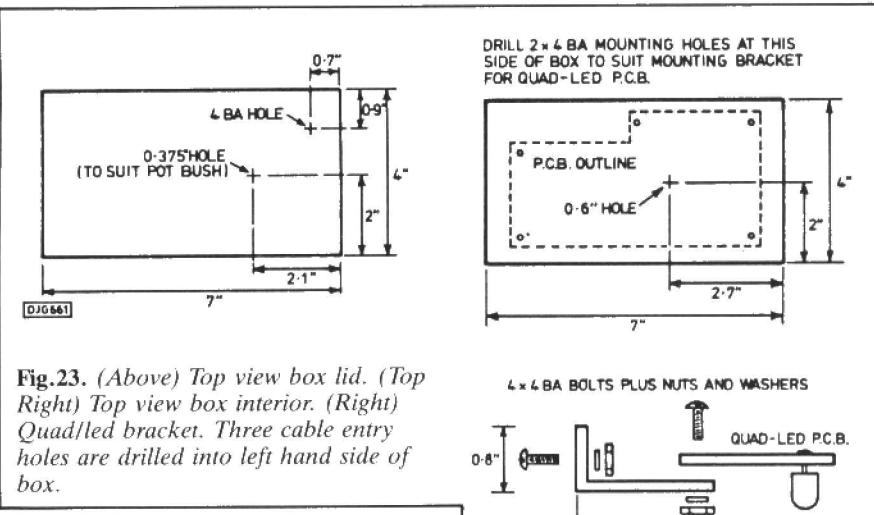


Fig.23. (Above) Top view box lid. (Top Right) Top view box interior. (Right) Quad/led bracket. Three cable entry holes are drilled into left hand side of box.

apparent detected speed only 5 mph. I admit to not being a theoretical mechanic, and so cannot offer an opinion on the efficiency of the cones suggested. All I can reasonably say is that in my own unit the arms rotated very freely both to touch and to light breezes. Certainly one of the key factors will be the amount of friction encountered. This should be minimised as much as possible.

As to how one really assesses rotor conversion efficiency I can only hazard a couple of guesses. Testing the unit in a wind tunnel would be one answer, but I hesitate to nip along to Rolls Royce, or to whoever else has one, and ask their help. I am also reluctant to stick the unit on the roof of the car and calibrate it while keeping an eye on the speedometer!

If anyone reading this actually knows a simple answer I'd be pleased to be told. But it's worth remembering that this is not meant to be a precision unit, and all that I am really aiming at are results that can be compared on a regular basis.

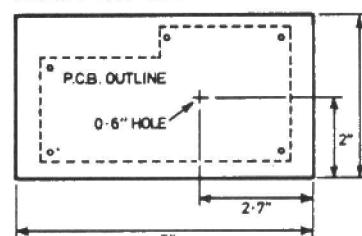
REMAINING ASSEMBLY

Obviously, the weather centre is split into two boxes. The one for use outside holds not only the detector circuits, but also has the wind speed rotor and weather vane mounted on it. This box is an aluminium one, measuring approximately $7 \times 4 \times 2.6\text{in}$ ($180 \times 130 \times 65\text{mm}$). The basic drilling details are shown in Fig.23. The mounting details for the speed detector sub-assembly pcb are shown in Fig.5 in part one. Fig.23 also shows the details for making and mounting the bracket that holds the wind direction sub-assembly pcb.

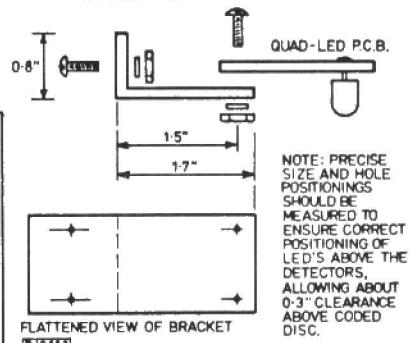
Then, Fig.24 shows how the weather vane is secured to its shaft and slotted detector disc. Although this is not an ideal engineering construction, it has the advantage of using readily obtainable electronic hardware parts. A few drops of light oil on the moving surfaces will help minimise the friction.

It's advisable to weather-proof the box as much as possible, for example, by

DRILL 2x 4 BA MOUNTING HOLES AT THIS SIDE OF BOX TO SUIT MOUNTING BRACKET FOR QUAD-LED PCB.



4x 4 BA BOLTS PLUS NUTS AND WASHERS



using grommets for the cable entry holes. The miscellaneous details for wiring the connecting plugs and sockets, plus the ldr and rain pcb are given in Fig.25. The gantry that holds all the detection gadgetry is then shown in Fig.26. None of it is hard to do, and I found a lot of pleasure in devising it. It's such a shame though, that model shops don't seem to stock these sorts of mechanical bits any longer. Indeed it's actually hard to find any model shops in my area, and those that are around only seem to stock plastic and balsa wood materials, and nothing more robust in metal than bits with which to make model trains. Perhaps in your area better facilities are available, in which case greater mechanical precision will be possible.

The control box is one of those steel and aluminium ones covered in black plastic measuring $6 \times 4.75 \times 1.8\text{in}$ ($150 \times 115 \times 45\text{mm}$), into which the necessary parts fit snugly — in other words plan it neatly! The wiring details are shown in Fig.27. Typical computer socket connections are also shown there.

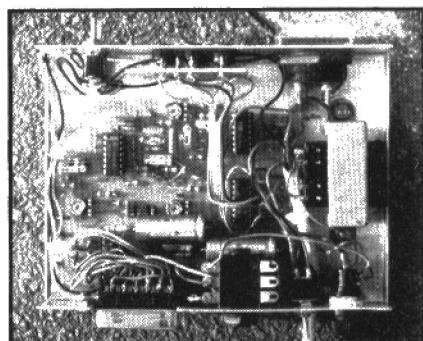


Photo: Interior control box

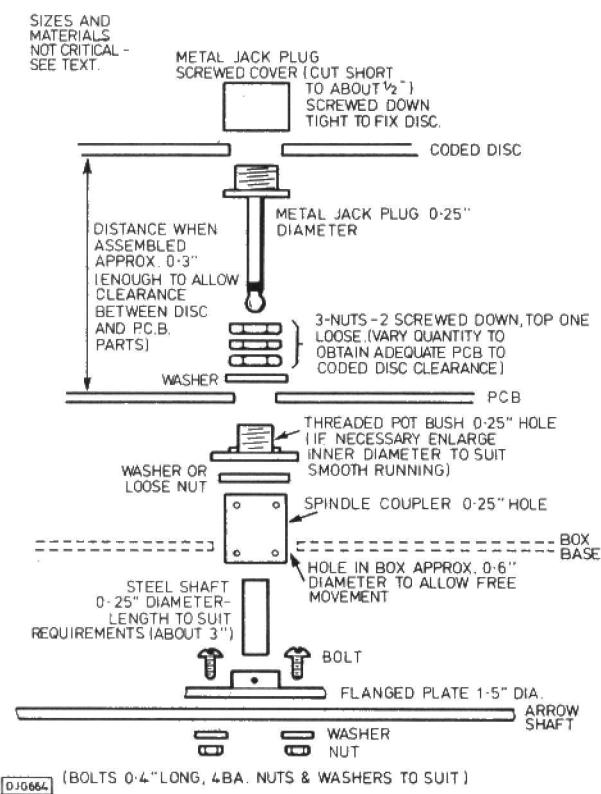
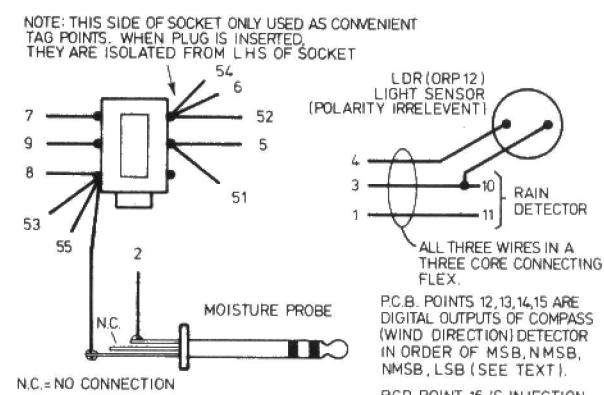


Fig.24. (Above) Wind vane shaft mounting

Fig.25. (Top right) Detector and interconnection wiring

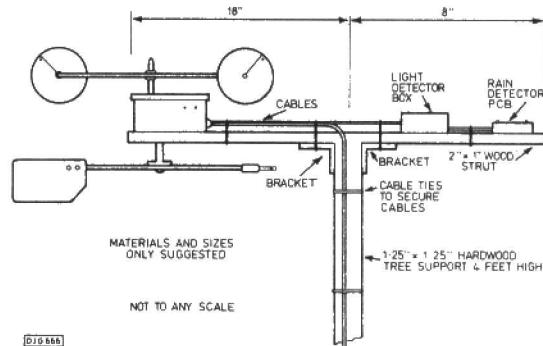
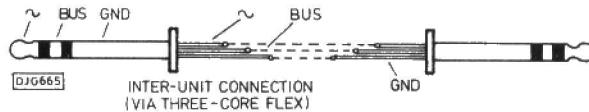
Fig.26. (Right) Gantry details

Fig.27. (Bottom right) Control unit and computer port connections



P.C.B. POINTS 12,13,14,15 ARE DIGITAL OUTPUTS OF COMPASS (WIND DIRECTION) DETECTOR IN ORDER OF MSB, NMSB, NMSB, LSB (SEE TEXT).

PCB POINT 16 IS INJECTION POINT FOR WINDSPEED SETTING UP (SEE TEXT).



OBSERVATIONS

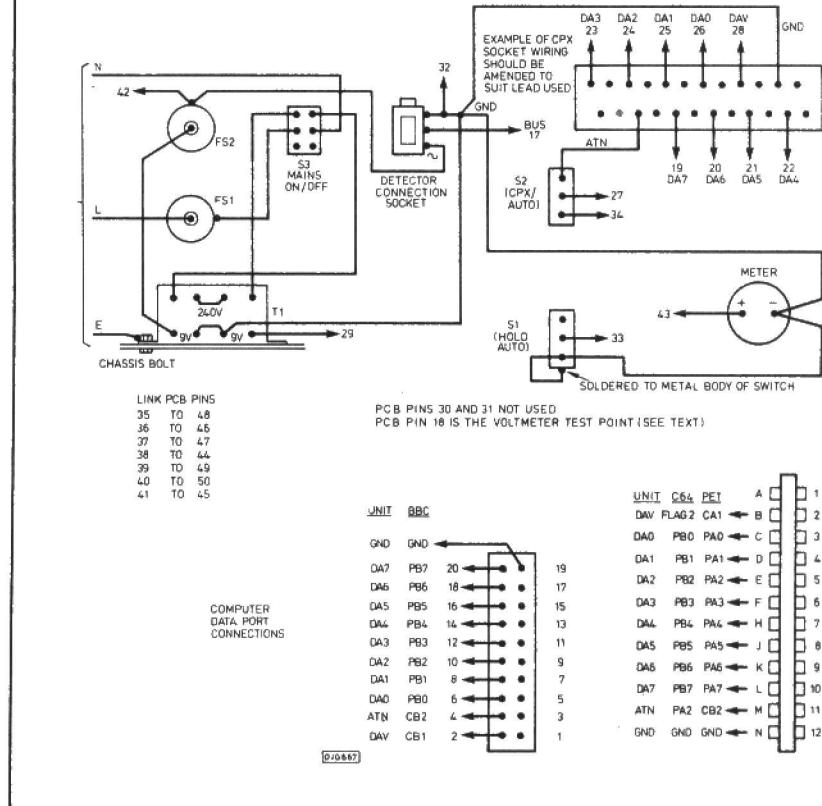
What has particularly interested me from observing the readouts is how variable wind speed is from one moment to the next. One moment the rotor can be rotating slowly, and at the next suddenly leap into high speed; and then fall back again. Wind gusting is far more prevalent than I had previously appreciated.

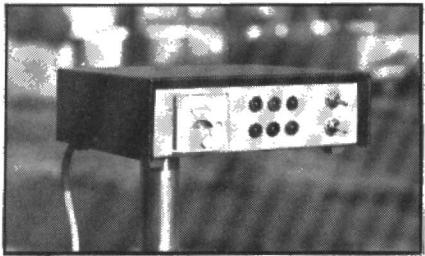
The wind direction detector confirms that the tv station transmitter is in the wrong direction for my roof aerial to ever stand a chance in a storm. So I'll stick with the portable one.

Daylight watching brings no great surprises, except that I am still trying to work out how to tell the computer the difference between a cloud, and a bird on the sensor!

There is conflict though, between light and temperature requirements. The latter really needs the unit to be in the shade, but even so, the temperature inside a sunlit metal box is quite revealing.

Watching the steady evaporation of water from the garden, and especially from indoor plant pots is another intriguing display — especially if you





observe the decimal places on a monitoring digital meter.

And the rainfall? Well, a depth detector is not included, but rainfall periods are quantified by the computer program. This records not only the start of rainfall, but also the time taken for the probe to dry out again once it's stopped. And yes, it has been a bit wet lately!

PREDICTION

As we've seen, all the detector circuits are for monitoring immediate weather conditions. In a future article I hope to bring you a barometric pressure detector, which will bring the possibility of weather prediction. Although one can go out and buy a barometer which has this rudimentary ability, it will be interesting to design and build an electronic equivalent. It probably won't predict hurricanes in Hertford, Hereford and Hampshire, or even round me in Kent, but I still hope to share the circuit with you.

PE

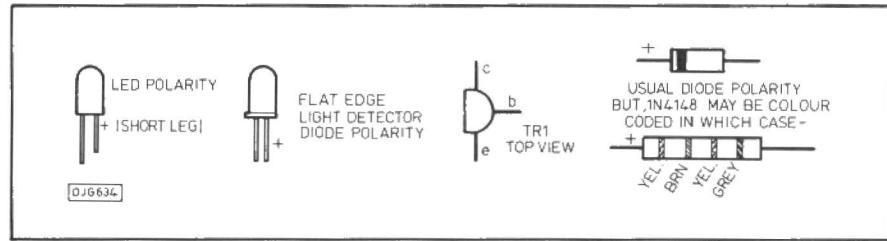


Fig.30. Semiconductor connections



Photo: (Top left) Control monitor unit. (Above) The detector unit - and your Ed. is taking no meteorological chances!

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1000 FFPRINT"J WEATHER CENTRE" SAMPLE" PRINT REM 450 19NOV88 : "2"=CLR SCREEN
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READERS' LETTERS

FURTHER HEARING

I was more than interested to read Mr Shaw's letter and your comments in PE Feb 88 on the subject of sound, particularly dialogue, on tv programmes.

As one whose hearing, especially frequency response, has deteriorated over the years, even with a hearing aid it has become increasingly difficult to interpret dialogue in the presence of 'realistic' background noises and music. A partial cure I find is to feed the audio output of my tv into the auxiliary input of the hifi and to listen on headphones, using the equaliser to gain better results.

My view is that dialogue is the better aid to interpreting a play, or whatever, than all the unnecessary 'realistic' background noises. It seems to me that what producers are saying is "never mind the dialogue, let's have the noise!"

As a former Post Office engineer at one time responsible for its provision of sound and vision programme circuits for the BBC, and remembering how fussy they were about frequency response and signal to noise ratio, I find it amazing that the BBC and ITA engineers allow all available quality to be destroyed by the producers in favour of so called realism.

I recall too, that BBC engineers were responsible for many innovations in the hifi field (I believe that Dinsdale of amplifier fame was a BBC engineer), and yet today they allow transmissions from 'boomy' studios. Even news broadcasts, which should be made under ideal conditions, are far from perfect – particularly from some female broadcasters!

M.W.J. Allan, Edinburgh.

Interesting comments Mr Allen. I assume that your last one is not conventionally 'sexist', but rather an observation related to the fact that female voices are generally pitched at a higher frequency than those of men, so where frequency restricted hearing is suffered female voices may well be less clear.

In addition to my previous comments, I also find that dynamic range presents problems in two areas. The first is that of the balance of subjective music and speech levels. When listening to the tv, a volume level that suits

comfortable hearing of speech frequently becomes far too loud for music tracks, necessitating turning down the volume to avoid premature deafness. This can sometimes result in an evening of keep-fit exercises, leaping back and forth between the armchair and the volume control (one day I'll splash-out on a remote control set). No doubt the meter needles on the transmission equipment are peaking at technically correct levels, but subjectively the speech and music volumes often come across non-equivalently.

The second dynamic range problem comes when listening to music tapes or transmissions in the car. The inherent noise generated by a moving vehicle frequently drowns out the lower volume passages of music, particularly symphonic and operatic music. Listening to such music in the quietness of one's home is perfectly satisfactory, and I acknowledge that varying music levels are necessary to the better appreciation of the composer's and conductor's interpretation of mood and emphasis. But in a car, when music is perhaps being listened to as more of a 'wallpaper' background than an intellectual experience, differing interpretive levels become problematic. There's probably no solution, though, other than constant knob twiddling. I doubt if the recording companies would consider issuing tapes with a compressed dynamic range so giving a constant volume to the music. Still, with enough pressure from car drivers they might...

Ed.

DECIMAL DRIVEL

Dear Sir,

There seems to be drivel written in the Midi Interface article in PE Sept 87 in that the Prof appears to labour under the impression that decimal 128 equals binary 1000. I can assure you that this is not the case.

G.J. Johnston, B.Sc., Kilmarnock.

It seems that the words that are printed and those that you read are not quite the same. If you read the relevant part of the article again, you will see that it refers to the most significant nibble being binary 1000, or decimal 128. Therefore the article does not say that binary 1000 is equal to 128, but that binary 10000000 equals decimal 128, which it certainly is.

The Prof.

BBC COMPUTER RADIO

Further to the letter in PE Mar 88 which commented on the radio interference caused by some computers, I was interested to read an article in a back copy (Dec 87) of *Radio Communication, the journal of the Radio Society of Great Britain*, concerning the BBC computer. The author, J C Worsnop, has experienced interference from a BBC computer situated three houses away from him. This was apparently capable of putting a 10µV signal into the author's 50MHz receiver, much to his distress.

He investigated ways of counteracting the problem and his published article offers a recommended solution to it. This largely consists of spraying the interior with a shielding paint, having taken suitable precautions!

No doubt the editorial office of *Radio Communication* will be pleased to sell you photocopies of the article. The address is Lambda House, Cranbourne Road, Potters Bar, Herts, EN6 3JE. The article is entitled *Reduction of RF Breakthrough from the BBC Microcomputer*.

Ed.

LONG GONE SILVER?

Dear Ed,

Please ask the readers if they can help me get an IF/40 parallel interface to connect between my Silver Reed EX43N typewriter and a Sinclair +3 computer. Even just a circuit diagram of one would help. The Sinclair people tell me there's an interface already in the computer and all I need is a connecting lead. Silver Reed say I need an IF/40 interface but don't know where I can get one.

T. McCormick, Shrops

ADVERT PRINT

Dear Ed,

I find that the print in some adverts in PE is far too small.

N. Clift, Swansea.

Yes, I agree, some advertisers do think that they can maximise sales by cramming a quart into a pint pot. I personally feel that if readers have to get out a magnifying glass then they are less likely to use the advertiser, preferring one whose ad is more easily read. However, the decision of how much to put in an advert is up to the advertiser, though I have occasionally expressed my concern to some of them.

Ed.

POWER CHANGE

Dear Mr Becker,

For 20 years I've been using a Multiblitz electronic flash unit which I am thinking of updating to use an electronic voltage booster instead of the mechanical one. Have you by chance a circuit coming up which might help me?

P.J. Gallagher, Co Cork

Dear John,

I want to drive a small fluorescent tube from a battery, have you a circuit for this?

J. Cowell, Tunbridge Wells.

Dear Ed,

I'm fed up with power failures each time we get storms. Can a car battery be used with any circuit to produce mains voltage that can cut in when necessary?

B.J. Knight, Kent.

Just a selection of letters of a similar nature, including one from a man living on a tug boat who wanted to power 12V devices from the boat's 24V supply.

Coming up shortly we have an article on converting power supplies from one level to another, both ac and dc, together with a circuit that produces mains voltage from a battery. It's over ambitious to expect a car battery to drive the entire mains equipment in a house, but low current converters for many purposes are easy to put together. The articles on switch mode power supplies in PE April and August 1987 show some ways in which this can be done. For ac to ac conversion all you need is a step-up or step-down transformer.

Ed.

HARD COPY

Dear Ed,

Sometimes PE publishes some tough words which I can't understand.

E. Rafeek, Kuwait.

Apart from suggesting you buy a better dictionary I'm not sure how I can help on this, though we are publishing an A to Z glossary of some terms in the near future. Your problem is minor to mine though, I was recently sent a copy of an Arabic electronics magazine, and I couldn't understand a word!

Ed.

BIPED

Dear Ed,

I have a major criticism about PE — it should be published twice a month!

J. Doyle, Crossneen.

As if I don't work hard enough already!

Ed.

SATELLITES

PART THREE BY MIKE SANDERS

ROOM FOR A LITTLE ONE

The future of communications satellites will see a shift to time division multiplexing, switching in space, extensions in publishing, navigational military and meteorological uses, and increasing demands on space overhead.

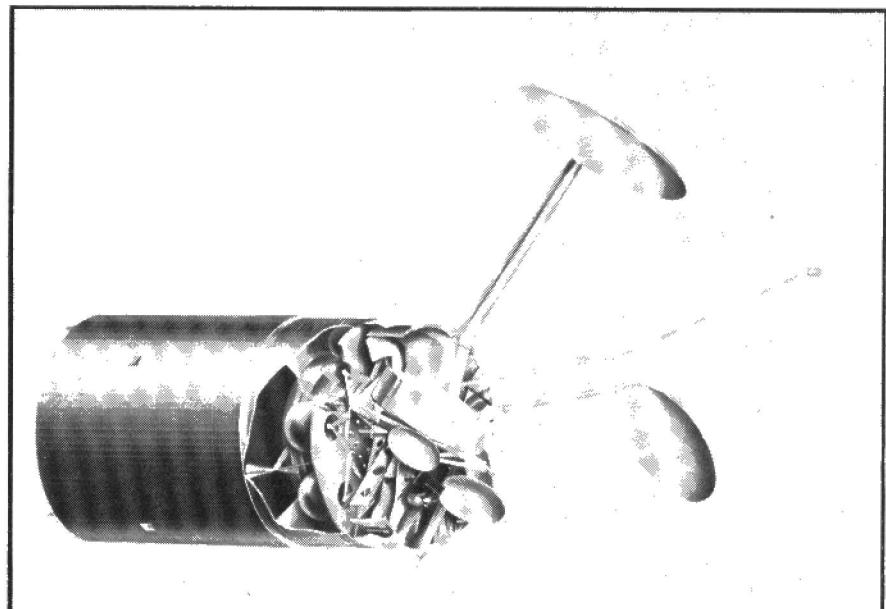
The next generation of Intelsat satellites will be Intelsat VI. It is capable of launch either by the US space Shuttle or by Ariane. After the Shuttle tragedy, it was quite likely to be launched by Ariane. However, since then Ariane has also suffered disasters, though without loss of life. Even without loss of life, the insurance companies have to pay close on \$100 million for a wasted satellite and launch.

Currently, launch failures are running at about one in seven, including satellite malfunctions. The space Shuttle is capable of launching several satellites but because it does not travel as high as a rocket, it carries a perigee motor in the cargo area in order to launch the satellite into its elliptical orbit.

Intelsat VI will return to the familiar drum shape made of two telescopic parts, the outer being 3.8m high and inner, 2.2m. Before launch, the satellite will be 5m high, and 12m high when fully extended.

As the analogue era gives way to the digital era, frequency division multiplex (fdm) will give way to time division multiplex (tdm) and time division multiple access (tdma) instead of frequency division multiple access (fdma). That is, with reference to Fig.1, instead of sharing out a frequency band between users, a number of users will utilise the same frequency band but shared on a time basis. For instance 30 people could share a single link if each transmitted a little information in a few microseconds in turn.

In addition to tdma, Intelsat VI will



Intelsat V

also use cfm (companded fm) which is simply compressed fm. Some argue that compressing fm in this manner reduces the fm noise quality to that of amplitude modulation.

A new technique which will be introduced is satellite switched time division multiple access (ss-tdma). This permits cross over of traffic from zone to hemispheric beam at the rate of 64 times in every 2 ms frame (Fig.2). Therefore each time slot is only $2 \text{ ms}/64 = 31.25 \mu\text{s}$.

The zone and hemispheric beams are shaped with the help of 146 feed horns at each aerial dish. The 14/11 GHz spot

beams are linearly polarised and steerable by ground control and show an example of the increasing part that ground telemetry is playing.

The 14GHz receiver within the satellite employs a gallium arsenide field effect transistor (GaAsfet) in the pre-amplifier. The power amplifiers are twts, but for the zone beams semiconductor power amplifiers are adequate since 3W is sufficient to carry traffic.

During the ten year operational life, the solar cells will have to produce 2kW by charging up 44Ah batteries. This is the kind of battery capacity required for

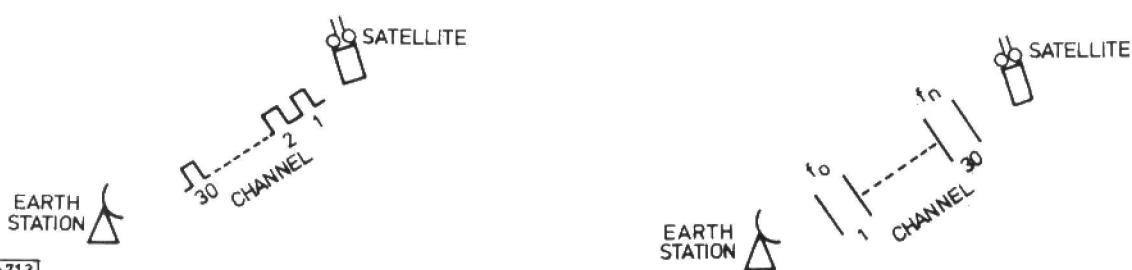


Fig.1. Left: Time division multiplex. Right: Frequency division multiplex

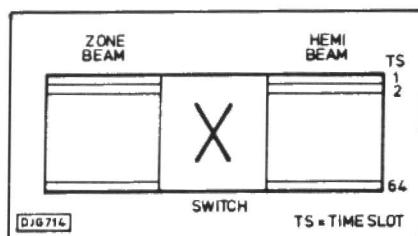


Fig.2. Satellite switched TDMA

starting up a car on a cold morning. Stability of the orbit is controlled by sun and earth sensors and a microprocessor to work out corrections.

AERIALS AT THE EARTH STATION

We have seen how the feeder can be placed to the side of a reflector to prevent blocking. There is another class of aerials called Cassegrains. These employ two reflectors: a main reflector and a sub-reflector. Fig.3a shows an open feed aerial and Fig.3b an offset.

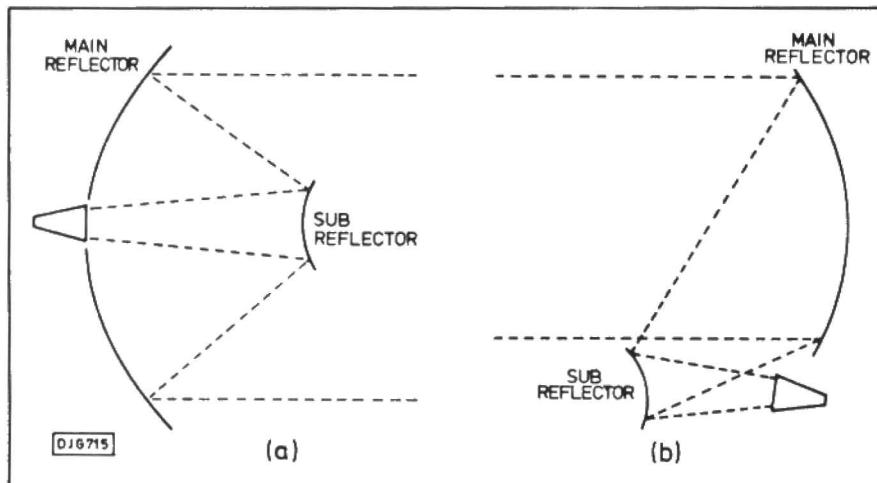


Fig.3. Cassegrain aerials. (a) Open feed (b) Offset feed

With Cassegrains, the main reflector is a parabola and the sub-reflector a hyperbola. The combination of parabola and hyperbola gives a better radiated wave pattern compared to a single reflector. In addition both reflectors can be altered in shape during manufacture to make small corrections to the wave pattern.

From Fig.3b it can be seen that the distance from the sub-reflector to the near edge of the main reflector is shorter than that to the far edge. Slight misshaping of both reflectors takes care of this.

Whenever a feeder is mounted directly in front of a reflector, the tripod is made not only thin but also elliptical to reduce beam blocking. Another type of aerial which is being used increasingly is the offset Gregorian (Fig.4).

The Gregorian arrangement avoids the need for a tripod and also generates a thin pencil of beam. These thin beams are essential when it is remembered

there are about 120 satellites in orbit, 90 of which are for communications, the rest are military or special application satellites.

If all 120 were strung out evenly on an equatorial orbit then each would subtend an angle of 3 degrees at the centre of a circle. When it is remembered that some of these satellites are bunched more closely, then it is not surprising that Intelsat has suggested that domestic satellite spacing be reduced from 2° to 1°, and 3° to 2° for international satellites.

The feed horn does not have to be near the reflector. In the open Cassegrain of Fig.3a, the feed horn could be on the ground and the beam conveyed to the main reflector by mirrors, as in Fig.5. The mirrors dispense with the need for a flexible waveguide but the mirrors need to be checked for alignment.

A good aerial will radiate low sidelobes and a symmetrical main lobe. Fig.6a shows a poor radiation pattern

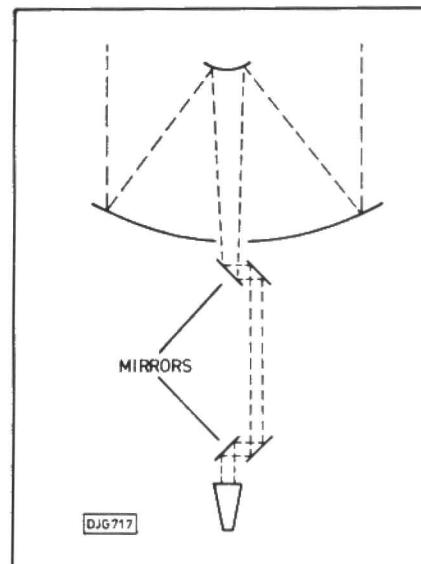


Fig.5. Mirror waveguide

and Fig.6b a good pattern. We have also seen that polarisations need to be separated by 30dB. All this is achieved by a number of different methods: lining the aerial horn with dielectric, manufacturing an aerial horn with steps, cutting grooves in the aerial horn.

Fig.7a shows an aerial horn with a single step and Fig.7b shows a horn with grooves. This makes the aerials heavier and more expensive but they work as follows. The step in the horn causes a higher wave mode which suppresses the fundamental mode and improves beam symmetry. But now the bandwidth is reduced and can be improved by putting more steps in the horn.

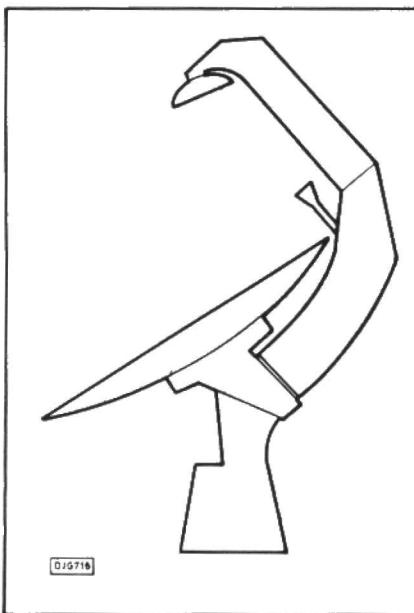


Fig.4. Offset Gregorian

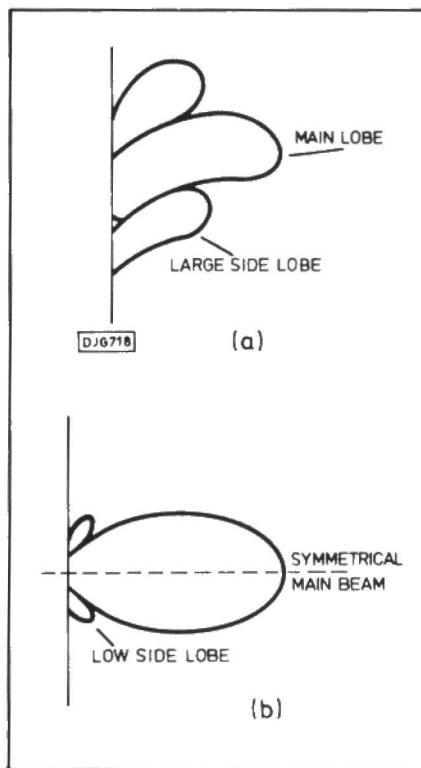


Fig.6. Radiation patterns
(a) Poor (b) Good

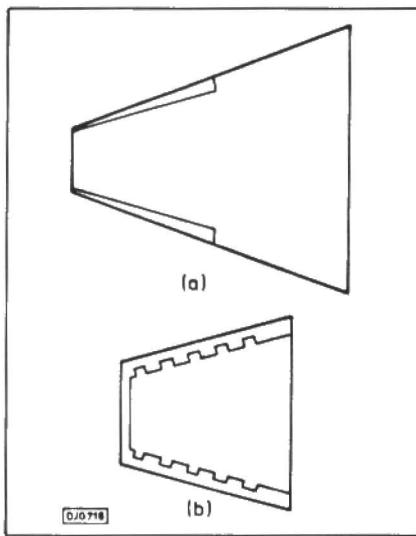


Fig.7. Aerial Horn (a) Steps (b) Grooves

In Fig.7 the circumferential field does not enter the grooves, only the electric field parallel to the axis does. The field pattern and therefore, frequency, depends on the depth and spacing of the grooves.

The very first aerial at Goonhilly in Cornwall weighed 1100 tons and used 100hp dc motors to track the moving satellite. The main dish was 25 feet (10m) in diameter and surrounded by 24 stainless steel petals to give an overall diameter of 85 feet (33m). At the petal joins, there are jacks for altering the shape of the dish to obtain an optimum beam.

Once the satellites were in geostationary orbit, 20hp motors became sufficient for the slight tracking adjustments. Also, once 14/11 GHz operations started, the aerial dishes became smaller which also meant that powerful motors were no longer required. With people requiring dishes in their back gardens and on office buildings, dish diameters are getting smaller. This means that the satellite must provide more power and 60W transponders are being talked about. Table 1 shows typical dish diameters and operating frequencies.

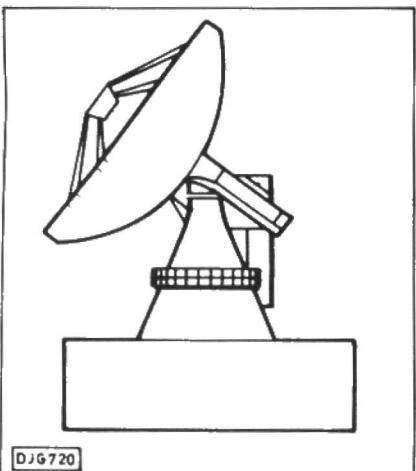


Fig.8. Early aerial tower

Early aerials were hoisted onto windmill-like towers (Fig.8), a post rotating within a tower 60 feet (23m) high. Modern aerials are more like Fig.9 swinging around horizontally on railway tracks, and vertically on a gear wheel. Even modern aerial structures are quite heavy, around 300 tons for a 90 feet (35m) diameter dish and because they usually sit on top of an equipment cabin, the cabin has to be reinforced.

Although aerials need to be light, they also have to be strong enough to operate in the face of 60 mph winds. The dish shape is unfortunate since it catches the wind and during gales of 120 mph the dish must be stowed facing skywards.

The Pacific Ocean Region has little interest for the UK. The busiest route is the Atlantic Region with traffic to the USA, and the Indian Ocean Satellites give access to Australia, Japan, Hongkong. Because the satellites are in equatorial orbit and England is some 50° North Latitude, the dishes appear to point towards the horizon.

At present there are two carriers of traffic from the UK: British Telecommunications and Mercury. British Telecom owns about half a dozen aerials at Goonhilly and another half a dozen near Hereford. Mercury owns a site at Whitehills near Bristol and also a site on the Isle of Dogs in London's dockland. British Telecommunications also have a site in the docklands.

INTELSAT AND EUTELSAT

Intelsat had 11 member countries when it was formed in 1964. There are now more than a hundred. Voting shares are determined by the traffic that each country generates over the satellites. Currently the UK has 11% and the USA 25%. Intelsat is an operational organisation and has a governing body called Comsat (Communications Satellite Corporation).

European Telecommunications Satellites (Eutelsat) was formed in 1977 to operate the European Communications Satellite (ECS). This was seen as satisfying a European need and of the 17 members, the UK and France hold the largest shares—16% each. Italy and West Germany have 11% each.

The first ECS was the Orbital Test Satellite (OTS) launched in 1977 and destroyed when the rocket failed. In 1978 a replacement OTS was launched and tested over three years. This was followed by regular ECS flights called flight one (F1), flight two (F2) etc.

In 1983 F1 was launched to operate in the 14/11 GHz band. Each transponder has a 72MHz bandwidth and beams television to Europe. There are 12 transponders of 20W power each. In 1984, F2 was launched with a tdma capability as well as a satellite multi-services (sms) capability. Multi-services implies that all

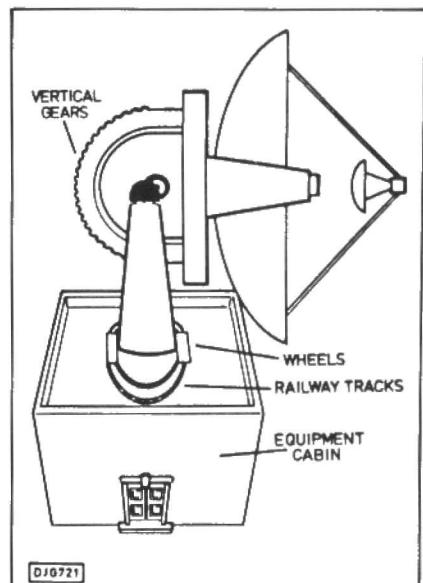


Fig.9. Modern aerial structure

traffic (voice video and data) are carried on the same digital path.

At present all ECS launches are scheduled for launch by Ariane, the European rocket. Flight 3 of the ECS I series was lost in the launch failure. OTS weighed 440kg but future satellites will weigh 650kg and Ariane will be upgraded to hurl this extra weight into space. A number of flights will be planned for each of the ECS series. OTS used 750W of power but future satellites in the ECS series will require 1300W and will employ solar panels like Intelsat V, making the satellites 14m wide.

SATELLITE APPLICATIONS

Apart from carrying telephony, satellites are used for other purposes such as studying and forecasting weather patterns, printing newspapers abroad, studying land and crops, broadcasting tv, for navigation and rescue at sea. We shall examine some of these in turn.

Broadcasting television by satellite is an enterprise that has developed in the past few years. Direct broadcast by satellite (dbs) will be launched in September 1989 by British Satellite Broadcasting for the UK. In the meantime, the French dbs satellite TDF-1 will

Table 1 Dish Diameters and Operating Frequency

Standard	Diameter (metres)	Operating Frequency (GHz)
A	32	6/4
B	11	6/4
C	18	14/11
D	4.5 or 11	6/4
E	3.5, 5.5, 8	14/12/11
F	5, 7, 9	6/4
G	1 to 32	6/4, 14/11
Z	6 to 13	Any

join West Germany's TV-SAT during the spring of 1988 and in September, Astra, the medium powered Luxemburg satellite with 16 channels will be launched.

One of the earliest tv channels broadcast via British Telecommunication's docklands aerial was Skychannel reaching half a million people in seven European countries. In June 1986, Music Box and Superchannel joined to form World Superchannel. At present 20W transponders are used on ECSI F1, but it is likely that such tv channels will utilise 50W transponders on subsequent generations of ECS.

Originally reception of tv via low powered satellites were meant for cable companies only. Now the Government's small antenna tv (smatv) decision means that hotels, hospitals, pubs and even individuals can erect small dishes 1.2 to 1.8 metres. These will be allowed where there are no cable tv operators.

WEATHER FORECASTING

Weather forecasting is another important application of satellites and man's struggle to master his environment. With thousands of passenger as well as cargo ships at sea it is important to be aware of impending storms. The automatic picture transmission system (apt) is used by many countries but this decade will see the use of weather satellites in geostationary orbit.

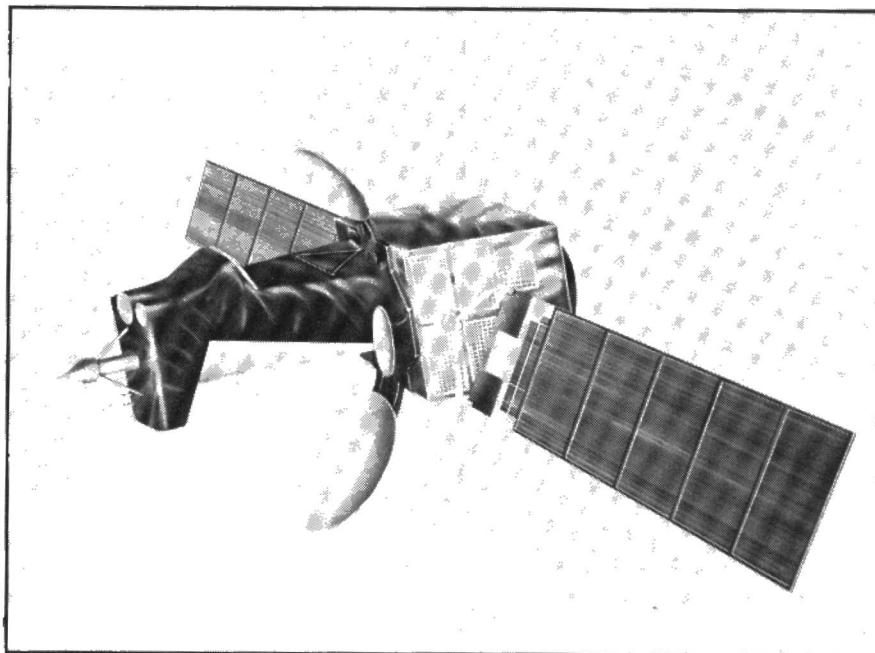
The USA uses the Geostationary Operational Environmental Satellite (GEOS). Three satellites are used to cover eastern, central and western regions creating a picture every 18 minutes. The body spins at 100 rpm and houses a camera which makes a west to east scan of the earth. On the next scan the instrument's mirror steps down one hundredth of a degree. The complete picture is made up of 1,800 scans.

The Japanese use the geostationary meteorological satellite GMS-3a which provides a picture every 30 minutes night and day, and also assembles data on ice floes and tides. The European Space Agency will use Sirio 2 and Meteosat 2, and India will use Insat 1.

Satellites have also been used to study geology for mining and more than a hundred countries have undertaken such studies either directly or employing one of the better equipped countries on an agency basis. Landsat was a project to study evaporation, soil temperature and crops, led by the USA and with seventy-five participating countries. In land sensing studies, a wide range of frequencies have been used, from the infra-red to the visible region.

NEWSPAPER TRANSMISSION

Printing foreign editions of a newspaper or magazine is one application just begging to be exploited. The advantages



Intelsat VI

are that news is immediate and air freighting newspapers is too slow for this purpose. Also freight charges are always increasing. By contrast, electronic communication charges have increased very little in real terms, taking inflation into account.

The Frankfurt and New York editions of the *Financial Times* are beamed up from a 5.5 metre dish operating at 128 Kbit/s. This has cut the cost of the American edition from \$1 to 50c which means that the revenue from advertising will increase if the circulation increases. In 1984, advertising brought in 14% of the revenue and also saved the £400,000 in freight which was expected to rise 33%.

It takes four to five hours to transmit the paper from a 5.5 metre dish in Ealing. Each page is loaded into a Muirhead facsimile machine and converted into 2Mbits of data in three minutes. Data buffers are then used to store the information so that it can be transmitted at 128 kbit/s.

Another paper that is transmitted via satellite is the Japanese paper Asahi Shimbun (Morning Star) which is beamed into the UK at 56 kbit/s. It has a circulation of 12 million and its monthly subscription charge has also been cut in half.

NAVIGATION SYSTEMS

There is a great demand for both time signals as well as standard frequency transmissions. Not only are such signals required by the general public but also by space and communications engineers, surveyors, geologists, navigators, astronomers, broadcast stations, etc. A primary time and frequency standard is obtained from caesium at the National Physical Laboratory.

Radio navigation and safety at sea are both taking a large step forward from the realms of radio ranging into the realms of satellite ranging. Anyone crying ufo in the future will have to be sure of his facts as more and more of these satellites go up to see and record everything that happens on land or in the air.

The World Administrative Radio Conference (WARC) has reserved bands in the frequency range 1.5GHz to 265GHz for radio navigation. The USSR uses their Tsikada satellites for their oil rigs and their navy.

The USA will replace their Navigation Satellite System with their Global Positioning System (GPS). The Defence department will spend \$8 billion placing satellites at an altitude of 20,000km and the facility will be available to civilians at \$370 with an 's' code giving a person's position to within 100 metres. Military 'p' codes will give a person's position to within 15 metres.

Safety at sea is something close to the heart of any seafaring nation. Although panic frequencies are allocated, there are more sophisticated systems which actually employ search facilities. Cospass is the USSR system for searching out ships and aircraft in distress. The UK, Canada, France, Norway and Sweden operate the Search and Rescue Satellite (SARSAT).

Little is known about military satellites. Some are stationary, others orbiting. Those that are orbiting change their paths and altitude during flights. It would not be difficult to find their operating frequencies, since the radio spectrum is already congested and these satellites most not operate at a frequency already allocated for another purpose. However, the transmission is invariably coded to prevent eavesdropping.

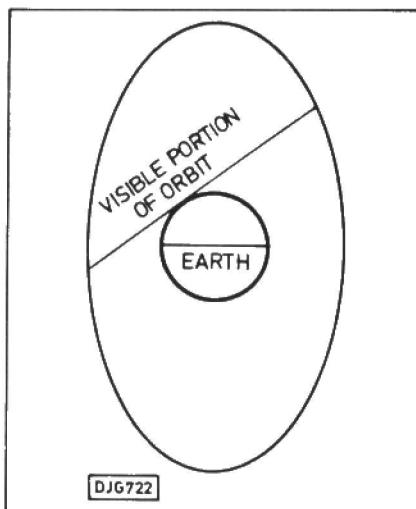


Fig.10. Molniya orbit

Another suggested application of satellites is for mobile radio. But since cars usually operate in cities with tall buildings, a satellite in equatorial orbit is useless. What is required is a very elliptical orbit which would make the satellite visible for at least 8 hours a day, Fig.10. The Russians call this a Molniya orbit and this orbit is very useful to them since the USSR launching and tracking stations are closer to the North pole than to the Equator.

CONCLUSIONS

We have seen how the early satellites grew rapidly in size to cope with increased traffic as well as multiple access. Although large countries were happy with fdm, small countries and the maritime services required Spade and scpc.

More traffic, including speech interpolation, demanded higher satellite power and this was achieved by increasing the area covered by solar panels on the satellite. Also the use of higher frequencies in the 14/11 GHz band compared to 6/4 GHz means that small aerials can be placed on rooftops and in gardens.

The next ten years will see traffic shifting from fdm to tdm as the demand for digital traffic increases. The use of large scale integration will enable a switching facility within the satellite. In the past it would have been unthinkable to place a switch in the sky since switches were bulky, heavy electromagnetic devices. The use of ss-tdma is only the start of things to come.

If television is beamed down to a cable tv operator, low power transponders are sufficient but as soon as a multi-service capability (sms) is required then high power transponders are required.

We have seen how satellites are used not only to carry speech and data but also print newspapers, mount rescue operations, broadcast tv, provide navigation, study crops, weather and geology.

Many abbreviations are used in con-

Table 2. Glossary of Terms

apt	automatic picture transmission	gfrp	graphite fibre-reinforced plastic
AOR	Atlantic Ocean Region	IOR	Indian Ocean Region
ARIANE	ESA's launch-rocket	INMARSAT	International Maritime Satellite
CCITT	Consultative Committee for International Telephone and Telegraph	INTELSAT	International Telecommunications Satellite
catv	community antenna television	MARISAT	Maritime Satellite
cfm	companded frequency modulation	MAROTS	Maritime Orbital Test Satellite
COMSAT	Communications Satellite Corporation	MARECS	Maritime European Communications Satellite
ces	coast earth station	NASA	National Aeronautics and Space Agency
csc	common signalling channel	OTS	Orbital Test Satellite
dbs	direct broadcast by satellite	psk	phase shift keying
dass	demand assignment signalling and switching	SARSART	Search And Rescue Satellite
dsi	digital speech interpolation	scpc	single channel per carrier
ESA	European Space Agency	sms	single channel per carrier, pulse code modulation, assignment by demand equipment
EUTELSAT	European Telecommunications Satellite	ss-tdma	switched satellite — tdma
ECS	European Communications Satellite	tasi	time assigned speech interpolation
fdm	frequency division multiple access	tdma	time division multiple access
GEOS	Geostationary Operational Environmental Satellite	twa	travelling wave amplifier
GMS	Geostationary Meteorological Satellite	twt	travelling wave tube
GPS	Global Positioning System	WARC	World Administrative Radio Conference

nexion with communication by satellite and a glossary is given in Table 2.

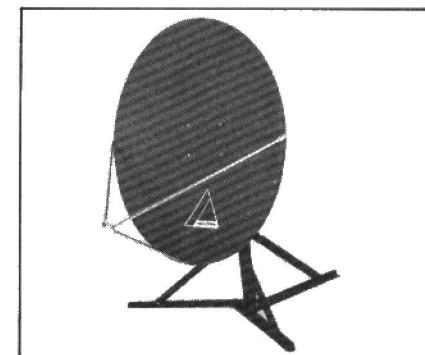
More satellites are due to go into orbit in the near future to join those functioning at present, along with the burnt out shells of past years orbiting like ghosts in the sky. Some satellites have obvious sounding names like Arabsat and Aussat. Others like Loutch and Statsionar have a Russian flavour while Webstar and Comstar are as American as hamburgers. The Indonesian satellite Palapa means "goodwill to all men". It remains to be seen whether military satellites will continue their passive role or take on a more active one.

PE

SPACE — THE NOVEL

I have just finished reading 800 pages of a novel called *Space*. Despite its title it is not SF, but an enthralling saga of America's exploration into space. Written by James A Michener, it begins with the German wartime research into rocketry at Peenemunde which resulted in the devastating V-bombs. Those involved in that research were acquired by the Russians and Americans at the end of the war in 1945, and were the fathers of the parallel technologies that produced the Sputnik Satellite and placed men on the moon.

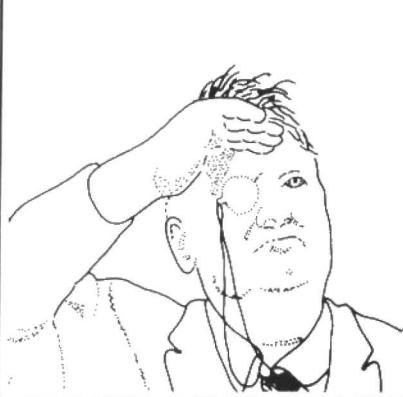
Though the continuing story concerns fictitious astronauts, the background is



Typical domestic satellite tv receiving aerial

set against the genuine activities and personalities of NASA through to the conclusion of the Apollo missions and the early days of the Shuttle. The story examines the complex experimentation, the inventive brilliance of the scientists and engineers, the heroism of the test pilots and astronauts, and the intrigues within government and the media. Through the evolving dramas we share the hopes, the achievements, and the failures of those whose vision is devoted to exploring the doorstep of a universe tantalisingly full of answers when we have the courage to look.

Space is published by Corgi at £3.95, ISBN 0-552-12283-1. Ed.



OUR REGULAR LOOK AT ASTRONOMY

SPACEWATCH

BY DR PATRICK MOORE

The mysterious Ashen light of Venus is to come under serious inspection during the summer. Perhaps it is the ghosts of the astronomers of Herstmonceux ...

It now seems that despite the efforts of astronomers all over the country, and support from both sides of both houses of Parliament, the fate of the Herstmonceux station of the Royal Greenwich observatory is sealed. Plans for the new building, at Cambridge, have been passed by the City authorities. The cost will be, officially, £3,000,000 — actually, of course, it will be much more when the final bill comes in. The telescopes at Herstmonceux will presumably be abandoned; the library and the archives will be dispersed; the fine Herstmonceux team will be broken up (a process which has started already), and arrangements at the overseas La Palma Observatory will be disrupted. What will be the benefits? Nobody seems to know.

It is expected that construction work at Cambridge will begin in September

1988, and Herstmonceux finally closed during the first half of 1990. The effects of this illogical and disastrous move will be long felt; it is a sad time for British astronomy.

On a more cheerful note, plans have been announced from NASA concerning the Galileo probe to Jupiter, which should have been on its way by now (taking in a pass of the asteroid Amphitrite en route). The long delay, due entirely to the Shuttle disaster, has meant that parts of the Galileo probe have had to be restored — including the parachute which will slow the probe during the descent into Jupiter's gas, the lithium sulphur dioxide batteries and much else. The cost of replacing the parts which have become unserviceable will be around a million and a half dollars.

The main problem is that because it

will have to be launched by a rocket much less powerful than that originally meant, Galileo will have to go by a tortuous route involving passes of the Earth and Venus! Launch is now scheduled for October 1989, but the probe will not reach Jupiter until the last part of 1995. I will have more to say about it shortly, but at least it is good to know that it is back on the official list. We can only hope that there will be no further serious trouble with the Shuttle.

Quasars continue to hold the attention of cosmologists, and some interesting new facts have been produced by researchers at Kitt Peak, Yale and New York. It is suggested that a quasar, which is the nucleus of a very active galaxy, may be 'brought back to life' after a dormant period by the close approach or collision of a separate galaxy. The

The Sky This Month

The evening skies through April are dominated by the presence of Venus, which is at its best, and which remains visible in the west for several hours after sunset. From North Scotland, it will in fact remain above the horizon until after midnight — something which does not happen very often! Jupiter is also an evening object, but is now well past its best for this apparition and will be lost in the twilight before the end of the month. Mercury is officially a morning object, but will not be seen with the naked eye.

The other bright planets, Mars and Saturn, are also in the morning sky. Mars has reached magnitude 0.5, but is still not well placed. Saturn is in Sagittarius, and rises in the early hours. It is well south of the celestial equator, but at least the ring-system is wide open, so that even in a small telescope Saturn is a glorious sight.

The Moon is full on April 2, last quarter on the 9th, new on the 16th and first quarter on the 23rd. There are no solar or lunar eclipses this month, but on the evening of the 18th, between 20 hours GMT and midnight, the Moon will be passing through the star cluster of the Pleiades, so that there will be some interesting occultations. Unfortunately the altitude will be very low.

No bright comets are expected — in fact Liller's Comet will probably be above the 7th magnitude, and therefore an easy binocular object, but it is too far south to be seen from Britain. However, we do have a meteor shower this month: the April Lyrids, which extend from the 19th to

the 25th, with a peak at or near 20 hours GMT on the 21st. The Moon will not interfere, and the ZHR may be at least 12. (The ZHR, or Zenithal Hourly Rate, represents the number of naked-eye meteors which would be expected by an observer under ideal conditions, with the radiant at the zenith or overhead point. In practice, of course, these conditions are never attained, so that the observed rate is always lower than the ZHR unless the shower is behaving in an exceptional manner.) At the end of April we may also start to see a few meteors from the Eta Aquarid and Alpha Scorpiid showers.

To all intents and purposes we have now lost the splendid stars of winter; Orion has vanished into the twilight, together with most of his retinue, though Capella, Procyon and the Twins are still visible. (Capella never actually sets over the British Isles, though when at its lowest it skirts the horizon.) The main spring constellation is Leo, the Lion, with the curved arrangement of stars forming the so-called Sickle; of these, Regulus is of the first magnitude. Look for Leo high in the south after dark. In the north-east the brilliant orange Arcturus has come into view. Much of the low south of the sky is occupied by Hydra, which has only one reasonably bright star even though it is the largest constellation in the entire sky. Ursa Major, the Great Bear or Plough, is almost overhead, while the W of Cassiopeia, on the opposite side of the celestial pole, is low down.

encounter fuels a gravitational powerhouse, probably a black hole, which, so to speak, 'triggers off' the quasar. Three examples of this process have been cited, and the evidence does appear strong.

THE ASHEN LIGHT OF VENUS

When the moon appears as a thin crescent, the night side can often be seen shining faintly. There is no mystery about this; it is due to light reflected on to the Moon from the Earth — as was pointed out, long ago, by Leonardo da Vinci. But it has been claimed that the same sort of effect is seen with the crescent Venus; the Earth cannot be responsible — and Venus itself has no satellite. So what is the cause of this so-called Ashen Light?

It was first recorded almost 200 years ago by the great German observer Johann Schröter, and since then it has been seen by almost every serious student of the planet, but its cause is still a matter for debate. There have been some curious suggestions: phosphores-

cent oceans, for instance, and even vast forest fires lit on the surface by the local inhabitants to celebration of the election of a new Government! But electrical phenomena in Venus' upper atmosphere seem to be a much more likely cause, though a few astronomers still dismiss the effect as being a pure illusion due to contrast.

Obviously, the only time to look for the Ashen Light is during the period when Venus shows up as a crescent, and conditions this month will be more or less ideal. The theoretical phase of Venus is 52% on April 1, decreasing to 47% on April 10 and 33% on the 30th; throughout May and early June the crescent will become more and more slender until inferior conjunction is reached in June 12. Note, however, that observed phase, during evening elongations, is always less than theoretical phase — a phenomenon due to Venus' dense atmosphere (I have called it the Schröter effect, since Schröter first noted it, and the term has not become accepted in astronomical

parlance!).

There is to be a comprehensive programme of observers, from April through to early June, with the aim of recording the presence — or absence — of the Ashen Light. A telescope of at least 6in aperture is needed, and it is wise to make a special 'occulting bar' to hide the bright crescent, but it is hoped that the results will be of value; up to now, observations of the Light have been depressingly spasmodic. Full details of the observing programme are given in the April number of *Astronomy Now*.

Venus used to be regarded as the planet of mystery. To some extent it still is; why does it spin from west to east, why has it no magnetic field, and what has happened to all the water it presumably once had? We do not know. And the Ashen Light itself provides another mystery, which only detailed, careful observation can solve. It is certainly well worth studying, even if we can no longer attribute it to enthusiastic demonstrations on our sister world!

PE

Astronomy Now

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LUNA MOODULE?

Legend has it that after the successful return of the Apollo luna missions a certain American research establishment became much upset at not being given moon rock samples for analysis. Having no further rocks to pass around a NASA official in desperation took

rocks from nearby farmland and sent them to the pestering researchers.

Some months passed, then NASA received a comprehensive report to the effect that though certain aspects of the rocks remained inexplicable they proved without doubt that the cow really had jumped over the moon!

POINTS ARISING

Recalling History Part Two. Jan 88.
Fig. 9. Page 41. Brown lead of 706 telephone should go to point 3, not to point 4. The original Telecom drawing was incorrect!

UPSTAIRS ALERT (MAR '88)

(Ingenuity Unlimited). TR3 should be a ZTX300 or similar.

SEMICONDUCTORS

PART 6: PRACTICAL MOSFET APPLICATIONS BY ANDREW ARMSTRONG

TURN ON TO THE POWER OF MOSFETS

The market for power mosfets is growing fast; soon they will outsell bipolar transistors. The home constructors market is generally behind industry, but power mosfets are now more easily available. Power mosfets have different advantages and disadvantages from bipolar transistors, so practical circuit design information is needed to make best use of them.

So far we have looked at the theory of circuit design with mosfets, and now it is time to put it into practice. In this part we will look at the design of blocks of power mosfet circuitry which can be incorporated into larger projects. The final block will be a mini project in part seven — a mosfet audio power amplifier module, for which a kit including PCB will be available.

STATIC CAUTION

Many applications which are difficult with bipolar transistors are relatively easy using mosfets, but be warned: there is one thing you must remember if they are to be an advantage rather than a liability. Static kills mosfets! Some of the smaller power mosfets, such as the ZVN106A, are much more vulnerable than cmos ICs.

Here is an example to illustrate the static problem. A subcontract PCB assembly company, despite specific instructions to the contrary, assembled boards, each containing three ZVN series mosfets, without specific antistatic precautions. On test, 50% of the boards were found to have at least one dead mosfet. The use of wrist straps to ground the operators (through a large resistor) and prevent static buildup, and slightly conductive antistatic bench mats, completely cured the problem.

This level of care may not be practical for the home constructor, but the following rules will minimise static damage. Keep the devices in conductive foam or wrapped in aluminium foil until ready to solder in to the circuit. Just before handling a mosfet, touch something which is earthed to discharge any static. Briefly touching any metal part on an earthed soldering iron (not the tip!) will do. Virtually any movement generates some static, so do it every time you go to pick up a mosfet. Make sure that the soldering iron actually is earthed. Insert the mosfet into the circuit last, so that the rest of the circuitry will dissipate any static which may build up subsequently.

GENERAL CIRCUITS

Power mosfets can be used to simplify a circuit which uses bipolar transistors. Fig.56 shows a bipolar relay driver for

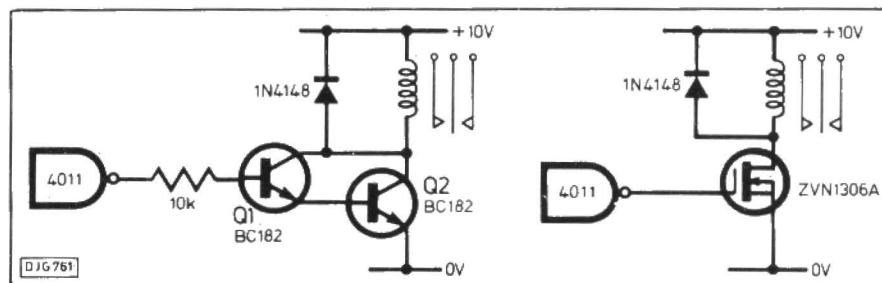


Fig.56. Comparison of junction transistor and mosfet relay drivers

use with a cmos gate, and the mosfet equivalent. Because a cmos gate is not rated to source much current, a darlington pair is required to give enough current gain to drive a relay. A base current limiting resistor is also needed. Because a mosfet is voltage driven rather than current driven, a single device can switch the relay, and no current limiting resistor is required.

Fig.56 shows a relay driver, but with the correct choice of component a single mosfet can switch loads of tens of amps under the control of a cmos gate. To do this effectively, it is necessary to consider several aspects of mosfet specification. The maximum continuous drain current rating of mosfets is specified, as is the ON resistance. These parameters are normally specified for a gate-source voltage of 10V. If the cmos logic controlling the mosfet is running on a 5V supply, then the gate-source voltage will only be 5V and the maximum current rating will be much lower.

For example, the typical characteristics of the IRF120 show a current of 3A at a gate voltage of 5V, and 16½A at a gate voltage of 9V. The ON resistance is correspondingly higher, so that even if a mosfet will switch the required current with 5V gate drive, it may dissipate more power than expected and require a bigger heatsink. In most cases, even with 10V gate drive, power dissipation limits the maximum current to about 70% of what the data book specifies. In reading manufacturer's data, do not confuse the typical performance with the worst case specification.

The IRF120, for example, has a worst case current capability of 8A, which would suggest that it is quite suitable for circuits operating at up to 6A. The

typical performance curves show it operating at over 16A, and many, but not all, would do so. It is important to read and interpret the data which manufacturers provide, and it is unsafe to assume that if a certain type of mosfet works in a prototype circuit then it will work in subsequent units.

The only other point to watch in controlling high currents with a mosfet driven by a cmos gate is that there is a high value of gate capacitance which must be charged and discharged to switch the mosfet on and off. In general, the capacitance is proportional to the current rating of the device. A cmos logic gate cannot charge and discharge this capacitance very fast, and may in some cases need a current limiting resistor in series with the gate terminal to prevent damage. High frequency switching is simply not possible if a cmos logic gate is used as the controlling element.

CURRENT SINK

In some measurement and control applications, a precision current sink can be useful. The circuit shown in Fig.57 uses the high output impedance of a fet to provide a high quality current sink. The current does not change measurably over a range of drain voltages between the minimum required by Ohm's law to make the specified current flow and the maximum for which the mosfet (or its heatsink) is rated. The mosfet on its own, fed with a constant gate voltage, would make a good current sink. The addition of the op-amp feedback loop makes it almost perfect.

A bipolar transistor current sink could not perform so well, because the current in the emitter resistor would include a contribution from the base current. With

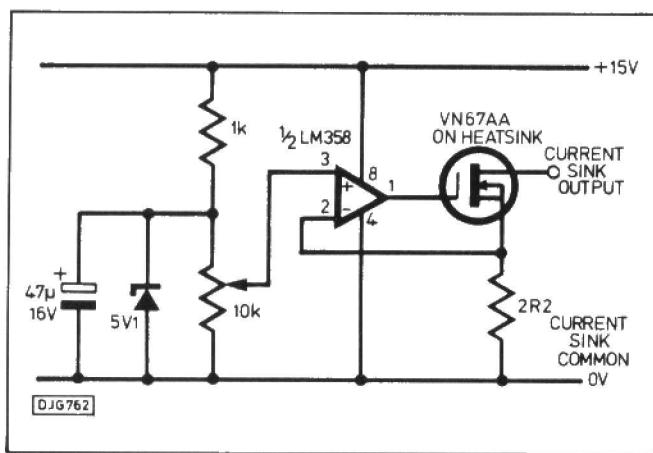


Fig.57. (Above) High compliance current sink

Fig.58. (Right) Low frequency astable flip-flop

the mosfet, all the source current also flows in the drain.

The high input impedance of mosfets can make them useful in timing circuits. Fig.58 shows two mosfets in an astable flip-flop circuit where, because no gate current flows, a long time period may be obtained by using very high resistor values. The frequency at which the circuit oscillates is set by the values of C1, C2, R3, and R6. Theoretically R2, R4, and R5 also affect the frequency but their values are chosen to make this effect negligible.

In contrast to the bipolar implementation of an astable flip-flop, this circuit is not inherently guaranteed to start oscillating. The addition of R5 and C3 ensures that at the moment of switch on an imbalance exists, and this starts the oscillation. C3 rapidly charges so that it has no further effect on the operation of the circuit.

SIGNAL SWITCHING

Power mosfets can be used to construct an analogue switch which is in some ways superior to the ic analogue switches. The circuit shown in Fig.59 has a lower ON resistance than ics such as the 4066, with a worst case figure of 7.5Ω . This would give under 1dB loss when inserted in a 50Ω line.

The signal isolation in the OFF state is good because there is an extra mosfet to short the signal in between the two

series fets. When the analogue switch is off, Q3 and Q6 pot down the signal by the ratio of a mosfet's OFF resistance to its ON resistance. In practice, careful construction should allow at least 60dB isolation at 10MHz, with better isolation at lower frequencies. This circuit is useful for rf, but is over the top for most audio applications.

Linear voltage regulator ics are widely used, but they are not always the best answer. The standard 78xx series need about 2.5 volts more on the input than on the output, and they consume about one milliamp to operate their internal circuitry. Low forward drop regulators, which need an overvoltage of only 0.5V to operate, consume around 10% of the total load current to operate their circuitry. Fig.60 shows a mosfet voltage regulator which gets round both these problems, and is suitable for low powered applications, for example in battery operated equipment. No zener diode is used, because the circuit regulates the output relative to the threshold voltage of Q4. This is not a precisely defined parameter, so different samples of mosfet will require different settings of VR1 to provide the same output voltage.

Current limiting is provided by R1, R2, and Q1. The value of R1 should be chosen to drop 0.6V at the maximum permissible current. To minimise forward drop in normal operation, the

limit current should be set to the maximum value which will not damage the regulator, rather than the maximum expected load current. If current limiting is not needed, omit R1, R2, and Q1.

FAST SWITCHING

All the applications so far have relied on slow switching or linear use of power mosfets. To make high current devices switch on or off quickly is difficult, because of the high gate-source and gate-drain capacitances. This is illustrated by the simple test circuit of Fig.61. It might appear at first that the gate-source capacitance C_{iss} (shown dotted) represents the most serious problem, because it has the higher value. In the circuit shown the worst problem is C_{rss} , because it has a waveform of the opposite polarity to the input signal on its other end, so the charge it takes from the input waveform is greater.

To make this clearer, consider the example of a 10V drive signal and a 40V power supply. The total voltage change across C_{iss} is 10V, while that across C_{rss} is 50V. If the value of C_{rss} is half that of C_{iss} , then its effect on the gate waveform is two and a half times that of C_{iss} . In many cases, the effect of C_{rss} is to cause a hesitation in the gate waveform, during which time substantial current flows in the source resistance R_s without the gate voltage increasing significantly. This is illustrated by Fig.62.

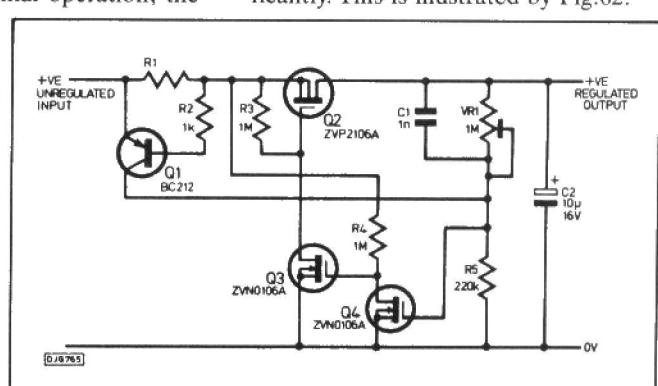
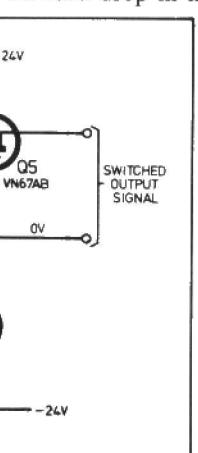


Fig.59. (Left) Ground reference analogue switch

Fig.60. (Above) Very low power consumption linear regulator

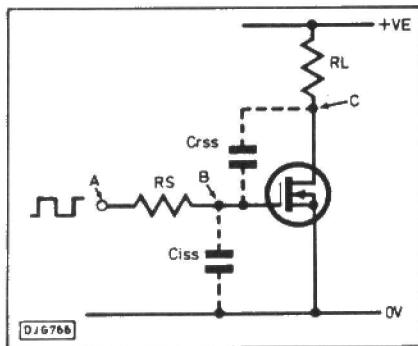


Fig.61. Fast switching test circuit

When considering power mosfet switching speeds, it is necessary to calculate the charge to be transferred to and from the gate capacitances, rather than imagining the effect to be like an ordinary RC circuit. As the waveforms of Fig.62 show, the charge transfer is not uniform over time, but is concentrated during the output switching period. In order to achieve specified switching times for power mosfets, a very high peak gate drive current is needed.

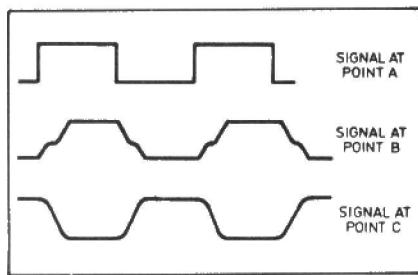


Fig.62 Charge transfer waveforms

The problem with long switching times, apart from the limiting of the maximum frequency, is that while there is current flowing in the mosfet and significant voltage across it, it is dissipating a lot of power. Switching at low frequencies causes no problems because the average power dissipation is low, but operation at high frequencies can waste a lot of power and make the mosfet very hot. This is of particular interest in switched mode power supplies and the like.

The 555 timer IC has a high current drive output, and is suitable to switch a power mosfet on and off fairly fast. In the circuit of Fig.63, the 555 is used to dim a 12V lamp by means of mark:space ratio modulation. The switching frequency is high enough to avoid visible flicker, but low enough to render the switching losses negligible. With the mosfet specified mounted on a heatsink, the circuit is powerful enough to control a car headlamp. Almost any power mosfet will work in this circuit, with the proviso that it is chosen so that its ON resistance is low enough to give a low voltage drop at the expected load current.

The circuit as drawn would make a low-loss torch dimmer, for voltages down to 6V. In this application, though, the

current is much lower than with a car headlamp, the BUZ10 or IRF541 or similar low ON resistance device is the best choice, because of the fact that the ON resistance is much higher with lower gate drive voltages.

If the dimmer is to be used on a car's electrical system the 555 should be fed via a resistor, and a 12V zener should be connected in parallel with its power supply, to protect it from spikes. I have used such a unit to dim a map reading light in a car to allow the passenger to read a map without distracting the driver. The circuit generated no detectable heat, while a resistive dimmer would have got dangerously hot.

SWITCHED MODE

Fig.64 shows a switched mode buck regulator which minimises the problems associated with mosfet switching by using the source rather than the drain as the output. The 78S40 switched mode power supply ic is designed to control a pnp transistor directly, so its output switches on when the series pass device is to be switched on. To switch on a junction transistor fully, and minimise the loss while it is on, a base current of 10% of the maximum expected collector current is required. This 10% current is drawn from the unregulated supply, so it represents a loss of 10% at maximum load, and more at lower load currents.

This circuit does not need a continuous base drive to switch the pass device on, and so is potentially more efficient. A bipolar transistor, Q2 is used to invert the output drive because it is in the wrong sense to drive an n channel mosfet, but Q2 dissipates little power.

If the gate of the mosfet were simply pulled up via a resistor to the unregulated supply voltage then it would not switch on very well. The source voltage would rise no higher than the threshold voltage below the unregulated supply voltage, which would cause substantial power dissipation. The bootstrapping capacitor, C2, raises the effective drive

voltage by an amount equal to the output voltage step (on the source). With the transformer voltage shown, this will be about 15V, which will turn on the mosfet very effectively.

If a higher voltage transformer is to be used, then a zener diode should be added between the gate and source of the mosfet to prevent gate insulation breakdown.

This circuit will give several amps output if the components are chosen appropriately. D1 is a Schottky diode, and should be chosen to have a current rating adequate for the expected load. A suitable 3A type is the Varo VSK 340, available from Electromail as part number 262-882. (*PE has no bias towards any supplier, and other equally good sources probably exist. Ed.*) A fast silicon junction diode would also work in this circuit, but would dissipate more power due to its higher forward drop. With a 5V output this can represent a major part of the total loss, though this is less significant with higher output voltages.

The current limit is set by R1. The 78S40 sets the peak current at the point when 300mV appears across R1. The average current is rather less than this, of course, and is about 2A for the values shown.

The output voltage is set by R6 and R5, and is given by the formula $V = 1.3(1+R5/R6)$. Any voltage above 1.3V may be chosen, so long as it is a few volts below the unregulated input voltage. If R5 is replaced by a potentiometer, then the unit becomes a variable voltage power supply suitable to power projects under test. If it is to be used for any critical purpose, an extra inductor like L1, and an extra 470μ capacitor should be added on the output to filter out any remaining high frequency switching noise.

The inductor may be wound on a ferrite pot core of the type intended for power applications (available from Electromail) if one happens to be handy.

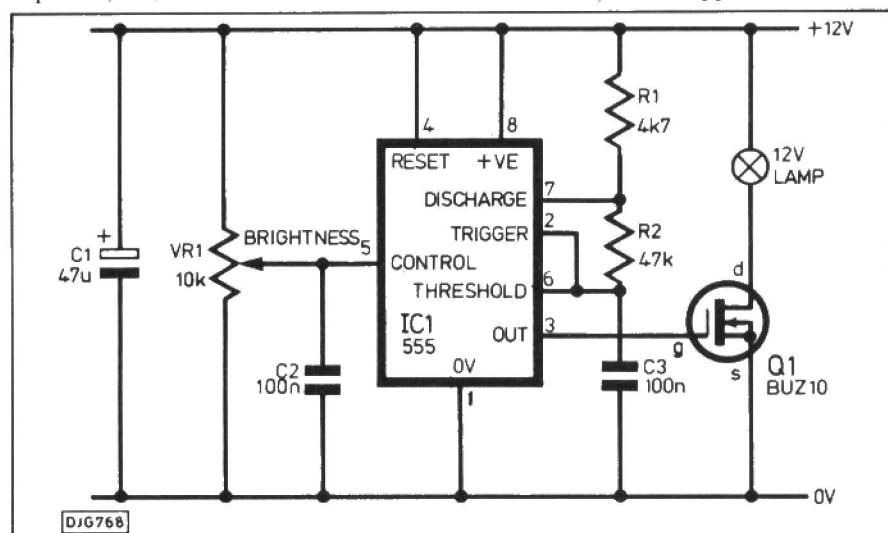


Fig.63. Using a variable mark-space timer for lamp dimming

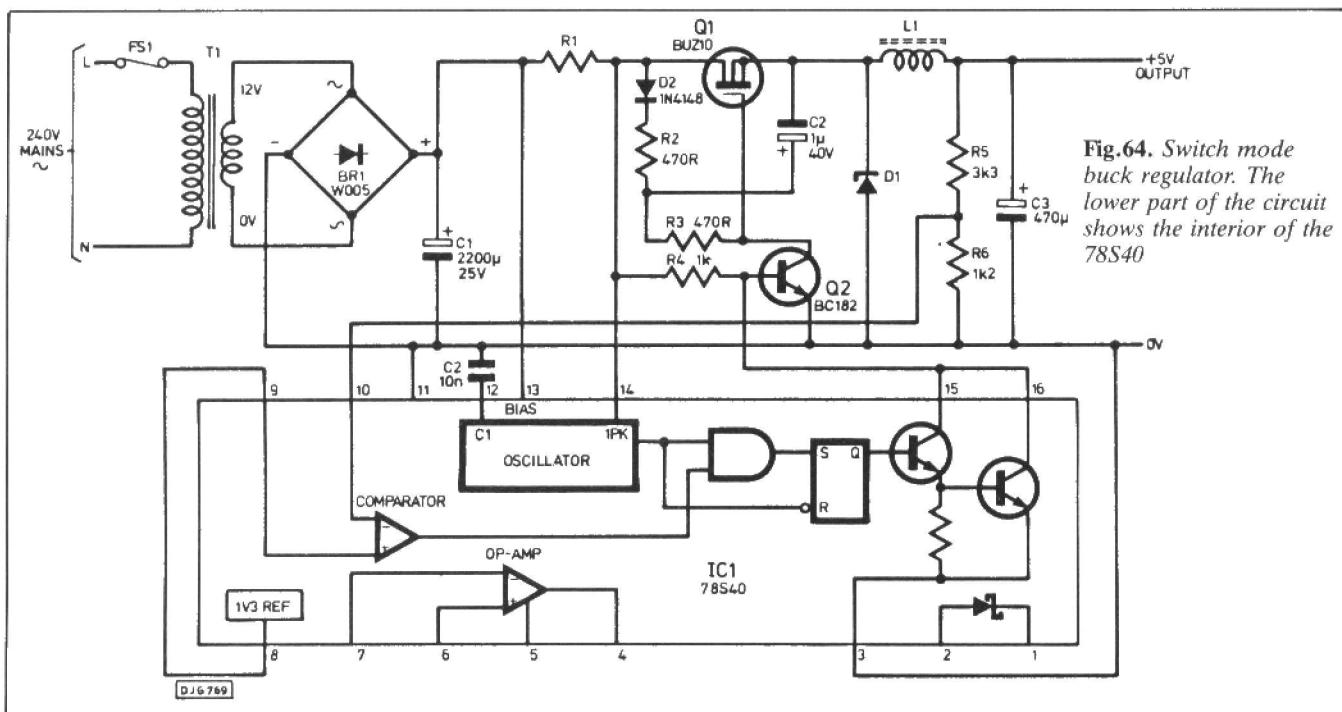


Fig.64. Switch mode buck regulator. The lower part of the circuit shows the interior of the 78S40

but a particularly good choice is a T94-40 core from Cirkit (part no 5509-440). If an RM10 pot core with an A1 of 250 is used then about 18 turns should be used. The T94 core requires about 50 turns, and has a much higher saturation limit, so will not saturate at any current which the mosfet is capable of switching.

To prevent the peaky current drawn from C1 from upsetting the control circuitry, C1 should be connected to the rest of the circuitry with short wires, or preferably mounted on the board with the rest of the circuitry. A Veroboard layout should work well, so long as the 0V connections are kept short.

Part 7 next month is devoted to a full blown project, a mosfet power amplifier. This is a simple design, using only discrete components, and it provides a very high quality sound. It is an example of how power mosfets can give high performance from relatively simple circuitry.

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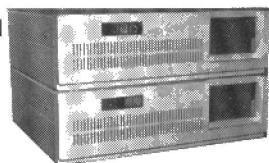
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INDUSTRY NOTEBOOK

BY TOM IVAL

RULING THE WAVES — NEW STYLE

The government's plans to hand the care of commercial radio to a new authority highlights the conundrum of government controls over the electronics industry: which is the fairest way? And are we talking about fairness at all?

The connection between Heinrich Hertz, William of Orange and Douglas Hurd may not be immediately obvious. It is in fact this very year, 1988. As well as being the hundredth anniversary of the discovery of electromagnetic waves by Hertz, it is also the tercentenary of Britain's political revolution of 1688 when William of Orange was set up as a constitutional monarch, depending for his position entirely on the good graces of Parliament. The later event led to the formation of the electronics industry; the earlier to a legislative system which influences that industry in various ways.

As for Mr Hurd, the present Home Secretary, he gave us this year an example of how the influence works, when he changed the system for regulation of commercial radio. He intends to remove it from control by the IBA and put it into the hands of a new 'light-touch' radio authority — as well as allowing community radio stations and national commercial stations to come into operation.

Parliament, through the governments it produces, influences the electronics industry in all kinds of ways. Some are through direct legislation, others through government agencies. Contracts are placed for such things as computers and military electronics equipment, companies are nationalised or privatised, financial grants are awarded or withdrawn, product standards are applied and business monopolies controlled. Trade with foreign countries is assisted and sometimes investigated, educational grants are made conditional on specific requirements, national initiatives like the Alvey project on information technology are set up, health and safety regulations are enforced, and so on.

Complex and varied as these activities are, they all boil down to the exercise of power. In practice this means making decisions based on some set of value judgements or political philosophy. Even the decision-making that results from mere expediency or crisis-management is a kind of principle of action in itself. And since political decisions (in the widest, non-partisan sense) are at

bottom ethical choices, one can see that they depend on interpretations of two main ethical aims which are held to be good: liberty and equality. By 'equality' I mean equal fairness, justice and opportunity for all.

There is a permanent tension between these two ideals. Untrammeled liberty can result in exploitation of the weak by the strong, so that equality is not achieved. Enforced equality can result in loss of liberty. But this inherent conflict is necessary for a civilised society. Finding the right balance is what the political factions are always arguing about.

I'm discussing these rather deep philosophical matters because they do emerge as guiding forces behind all the governmental decisions that affect our industry. A good example is the way such decisions bear on the very resource that Hertz discovered. I mean the allocation of radio frequencies to different services and their assignment to particular users.

Allocation to various services (broadcasting, communications, navigation, amateur etc) is decided by international agreement. The government sends a delegation to each World Administrative Radio Conference that is responsible for making these decisions. This delegation knows in advance how it would like to see the spectrum carved up.

It arrives at this desired apportionment largely as a compromise between the claims and counter-claims of different national pressure groups — say the broadcasters versus the mobile radio interests. Once the international allocations are agreed by negotiation, the government makes assignments to individual users, again under pressure from those who actually want the frequencies.

Thus the government is having to make value judgements all the time on the conflicting needs or wants of different users of the frequency spectrum. It's not a very good system because the government finds itself acting passively or even defensively, in response to self-interested demands. Too often it's the richest or loudest pressure groups who get the best deal.

What is needed is some kind of value

analysis which is independent of mere claims. In other words, frequency space would be allocated more fairly if it were done on the basis of relative social needs. But there is no objective data from which these relative needs can be calculated straightforwardly. They can only be derived from the value systems prevailing in a society. The government would have to analyse these values in some way that would allow it to quantify real needs for frequency space. To be accepted, the analysis would have to be demonstrably rational and so obviously right and fair that no reasonable person could disagree with it.

Unfortunately this kind of analysis, although seen to be desirable, is beyond the powers of our legislators. Perhaps the nearest type of thing we have already in the UK is the mathematical (computerised) model of the economy — sets of equations into which changing data are fed to obtain forecasts — because this kind of model does have to take human behaviour into account. In the USA the National Academy of Engineering has looked at the problem and at least recognised the importance of social and economic factors in spectrum management.

Of course, other methods of allocating and assigning frequencies have been suggested. One is that spectrum space should be sold to the highest bidder. The thinking behind this is that the more you have to pay for your piece of territory the more economic pressure there will be on you to use it efficiently. Another suggestion is to allow a free-for-all in certain bands, on the principle that some kind of adjustment will occur naturally and make formal regulation unnecessary. Methods of this kind would be both unworthy of a civilised society and a cop-out by those who should be making the decisions — our legislators.

Under the present government the mechanism of market forces is held up as a good principle in itself as a way of allocating resources. It's certainly efficient in an economic sense and many voters obviously approve of this philosophy. But whether it also results in a fair and just allocation of resources to everyone in our society is a very questionable matter.

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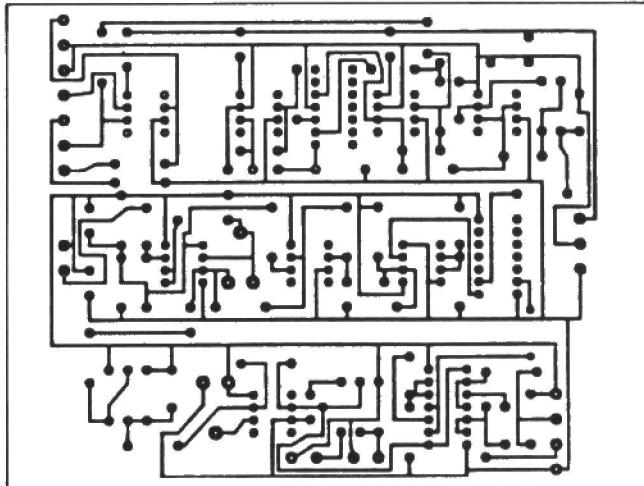
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